

**COMPARING STUDENT ACHIEVEMENT AND SATISFACTION IN
TECHNOLOGY INFUSED (HYBRID) AND TRADITIONAL CHEMISTRY
CLASSROOMS**

by

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ABSTRACT

Despite the growing use of the hybrid course delivery format in science education, there is a scarcity of research to support its effectiveness in enhancing student learning at the secondary school level. My research explores how a hybrid mode of course instruction compares with the traditional offline face-to-face mode of instruction in terms of student achievement and satisfaction. In order to assess the differences between the two course delivery formats, student satisfaction and achievement levels were measured in two Chemistry 12 classes. Findings demonstrated that students in the traditional offline face-to-face class were more satisfied than students in the hybrid class with respect to perceptions of course content and communication levels with the instructor and peers. With respect to students' satisfaction with given grades and access to course materials, both the traditional offline class and the hybrid class yielded similar findings concerning course satisfaction. Results overall also showed that students in the hybrid class did not perform any better or worse than students in the traditional offline face-to-face class. Rather, student achievement and satisfaction levels in the hybrid format seem to depend on multiple factors not reducible to choice of format.

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The 21st century is a fundamentally different environment that is demanding completely new ideas for how things get done. These sweeping changes are occurring so rapidly and are of such magnitude that education must quickly adapt or face the very real prospect of becoming irrelevant.

Jukes, McCain, Kelly (2009, p.1)

1 INTRODUCTION

1.1 Hybrid Learning

Right now in British Columbia (BC) schools, one can find at least three modes of instruction: traditional offline face-to-face (F2F), distributed learning, and a hybrid of traditional offline and online modes of learning. Current data obtained from Learn Now BC, indicates that 47 school districts out of a total of 60 school districts in BC offer some form of distributed or hybrid learning in addition to the traditional offline, F2F instructional format (Virtual School Society, 2010). In one particular school district in BC, for example, 124 schools within the district have been moving towards adopting technology-based instruction, whether it is on site or through the Distributed Learning Centre. At present, there are classrooms that use hybrid instruction and those that use traditional offline face-to-face (F2F) modes of instruction. In the school where this study was conducted, the adoption of technology-based instruction was embraced in a very guarded manner — especially by science teachers. For example, out of 28 science classes offered over two semesters during the 2009/2010 year, only 8 of these classes were delivered via the hybrid course format. Although hybrid learning is being adopted at schools in the district, there is a scarcity of research regarding its effectiveness in terms of student achievement and satisfaction when compared to the traditional offline format at the secondary school level. Research on this

mode of instruction would provide educators with information and data that may be used to implement hybrid courses within the secondary school level, and to ensure that these courses are viable. The results of research on these two modes of instruction are not definitive and by no means limited to secondary school students. For instance, while a number of studies have found that course grades in hybrid and traditional offline format courses differ (Riffell & Sibley, 2005; Gutierrez & Russo, 2005; Wellburn, 1996; Vilkoniene, 2009; Waite, 2007; Gutierrez, 2004), other studies have reported no difference in students' scholastic results when hybrid teaching materials have been used (Baki & Guveli, 2008; Johnson, Aragon, Shaik, & Palma-Rivas, 2000). However, no studies examining the differences between academic performance and satisfaction among students in the hybrid environment at the high school level in Chemistry education have been identified in a review of the literature. The purpose of this study then, is to compare levels of secondary student satisfaction and achievement in a traditional offline chemistry class with those reported in a hybrid Chemistry class.

1.2 Research Questions

The following research questions were investigated in this study:

1. Is the mode of course delivery associated with a difference in student satisfaction?
2. Do Chemistry 12 course grades differ in traditional offline and hybrid course delivery formats?

1.3 Hybrid Learning – An Overview

While high school students of today possess unequaled technical aptitude when it comes to web-based learning environments, they may require the presence of a classroom instructor to provide encouragement, support, and guidance. While broadening the breadth and scope of courses by integrating “new media” technology, hybrid learning attempts to continue emphasizing the fundamentals of support, encouragement, and motivation at the personal level. Hybrid learning (also called blended learning) is the term used to describe learning or activities where e-learning, in its various forms, is combined with more traditional offline forms of education such as "class room" training (Stockley, 2009). According to the Michigan State University Virtual School, the goal of a hybrid class is to combine features of in-person instruction with technology-enriched online experiences to create an educational atmosphere that promotes active, participatory learning. The concept of hybrid learning, however, is not simply a combination of online and face-to-face (F2F) instruction. Rather, it focuses on optimizing achievement of learning objectives by applying the “right” learning technologies to match the “right” learning to the “right” person at the “right” time (Graham, 2005,). As is evident by the studies presented in the literature review which follows, achieving the correct mix of technology and face-to-face instruction embedded within different course designs does not always result in the optimal teaching and learning experience. The implications that this presents for my research are based on ensuring that the optimal balance is attained between the online and face-to-face components, including addressing intended student learning outcomes prior to delivery.

The challenges inherent in online learning, such as the lack of face-to-face (F2F) interaction, may be addressed by hybrid learning (Dziuban, Moskal, & Brophy, 2007) because teachers are available to guide students and encourage those who may, for one reason or another, fall behind. At the same time, the web-based aspects of hybrid learning reduce the need for large orders of expensive, constantly revised textbooks. Instead, the teacher can update and modify course content as necessary. Students are also less restricted by the progress of their peers and can work at their own pace. Ultimately, students who participate in hybrid learning may also acquire a demonstrable advantage in their overall technological competency (Oblender, 2002).

Although hybrid learning is increasingly viewed as a highly effective method of course delivery, generally positive feelings about it among teachers have been qualified by expressions of caution (Reasons, 2004). Studies consistently demonstrate that the majority of online learners prefer regular face-to-face contact with their instructors and tend to perform better in their courses when this contact occurs (Riffel & Sibley, 2005). There is also concern that the hybrid course delivery format may result in increased confusion among students as they try to move between the online and traditional offline portions of the hybrid-learning environment (Reasons, 2004).

Within the larger framework of hybrid learning, there are two unique models: the “web-enhanced” classroom and the “hybrid-classroom”. In the “web-enhanced” classroom, most of the learning occurs in the traditional offline classroom, with a supplementary online component to support the face-to-face instruction. An instructor might, for example, post the course outline online, along with the assignments – thereby reinforcing the line of communication between teachers, students and parents. Weekly self-paced learning

involving multimedia presentations, online quizzes, and Internet links might be used to provide extra resources to further support students' learning. On the other hand, the "hybrid-classroom" differs from the web-enhanced model in its greater reliance on Internet-based learning, though the face-to-face component remains crucial. The hybrid-classroom may allow for both an extended school day and an extended school year, permitting a greater range of learning activities to occur outside the classroom walls. As a generalization, the time students spend online within the hybrid-classroom environment is both characteristic and crucial to the success of this course delivery format. A class might, for example, meet three days a week, devoting two full days out of every school week to the online experience. Alternatively, a class might meet every day, with a component of the day's lesson presented online.

The success of hybrid learning is highly dependent on the way that professional development, technical support, and curriculum support are combined, and whether or not a specific "mix" becomes effective for both instructors and learners. As with all forms of course delivery, effective professional development of teachers is especially crucial, both before and during teaching engagements. Within the hybrid-learning environment for instance, instructors must fully understand the various benefits that the hybrid approach delivers, how the approach may assist students to master presented material, and how hybrid-learning instruction methods may provide teachers with an option of delivering course content. At the same time, any hybrid-learning program requires significant technical and curriculum support. Websites used as part of a "web-enhanced" or hybrid-classroom instructional model must be consistently available and reliable, must conform with guidelines regarding students with visual, auditory and other disabilities, and must be able to repel

efforts by “hackers” and other intruders to manipulate site content. The success of hybrid learning modes therefore requires significant support from the school on multiple levels.

2 A THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 Theoretical Framework

In 2005, C. R. Graham, writing in “Blended learning systems: Definition, current trends, and future directions”, offered what is, in many ways, an idealized definition of the “hybrid” or “blended” learning environment while simultaneously pointing up its inevitable lack of clearly-defined structure:

Blended Learning is an approach to blend different learning methods, techniques and resources and apply and deliver them in an interactive meaningful learning environment. Learners should have easy access to different learning resources to apply the knowledge and skills they learn under the supervision and support of the teacher inside and /or outside the classroom. Such approach may apply face-to-face instruction with computer-mediated instruction. It also applies science or computer laboratory activities with the assistance of innovative educational technologies through computer, cellular or I-phones, Sky TV channels or any other electronic media. ...The terminal aim of blended learning is to provide realistic practical opportunities for learners and teacher to make learning independent, useful, sustainable, and ever growing (p. 3).

The theoretical framework that offers the clearest and most concise model of organization for hybrid-learning programs is Badrul Khan’s Octagonal Framework. This framework is about ways to plan, deliver, manage, and evaluate hybrid-learning courses. It is a theoretical model that serves as an instrument to aid in selecting each delivery option individually or as a whole to create and deliver a hybrid-learning course. The strongest feature of the framework is the way that it allows those constructing hybrid-learning programs to pick and choose from relevant “ingredients” and combine those ingredients in a

way that helps educators and students reach specific goals. Khan's model helps educators plan, develop, deliver, manage, and evaluate hybrid-learning programs, not least in helping them to avoid ineffective delivery systems that fail to provide adequate return on time, energy, and resources invested (Singh, 2003). Harvey Singh (2003) offers succinct justification for the increasing prevalence of hybrid learning and the specific role of Khan's Octagonal Framework in helping to provide educators with direction in formulating hybrid programs: "Learning requirements and preferences of each learner tend to be different [and demand] a blend of learning approaches...to get the right content in the right format to the right people at the right time" (pp. 51-54). The objective of Khan's Octagonal Framework is full synchronization of content, format and learner, and to this end, it offers eight specific dimensions of the hybrid-learning environment that should not be neglected.

The first of these dimensions is *institutional* and refers to issues surrounding organizational and administrative elements of a hybrid-learning program, as well as academic affairs and student services. Khan himself is adamant that serious focus on the institutional elements surrounding any hybrid-learning program is intrinsic to the success of that program. After all, attracting, engaging, and maintaining the interest of students is central to the success of *any* educational program – hybrid or not. As Khan puts it,

Institutions offering e-learning should consider online students as the consumers of education and training in a competitive market. ...[Learners] have more options to compare quality, services, price, and convenience of educational providers. It should not be surprising that distance learners demand far more services than traditional offline campus-based students, [and] ...institutions should be ready to provide high quality education and training, with the best learning resources and support services (Khan, 2005, p. 23).

Course organizers might concern themselves with the overall readiness and ability of an organization or educational facility to actually offer a hybrid-learning course, and focus specifically on content availability, technological capacity, and learner requirements (Singh, 2003). Educational budgets, admissions, tuitions and fees, financial aid, registration and payment, IT services, instructional design and media services, graduation, transcripts, and grades also fall within this category (Khan, 2005). A comprehensive “needs analysis” often characterizes this institutional dimension of Khan’s model. As Khan puts it: “Needs analysis will help institutions analyze the short-term and long-term needs for their e-learning initiatives, and in turn will be instrumental in developing their e-learning strategies” (2005, p. 23). The success of hybrid learning programs depends on comprehensive institutional support.

The *pedagogical* dimension is concerned with how content is combined in preparation for delivery (content analysis), the relationship between content and learner needs (audience analysis), and overall learning objectives (goal analysis). Design and strategy aspects of hybrid learning also fall within the pedagogical realm. Khan’s framework suggests that within the pedagogical dimension, there should be an effort to match program goals with content delivery methods. Relevant considerations include what sort of content should be taught online, and what is best suited to the classroom, which course content might benefit from delivery through multiple channels and what can be considered static (unchanging) or dynamic (subject to change over time). Taking a closer look at exactly *who* is being taught (i.e., what is the exact nature of the audience receiving instruction) and how that audience might vary or expand in a hybrid program is a question that affects all other

pedagogical considerations. Rosenberg illustrates how these critical considerations can greatly facilitate the effectiveness of content delivery:

...[L]aying a foundation for a house is probably best taught on the job by a skilled craftsman. But if a construction worker someday wants to own his/her own home-building business, she/he better learn a little bit about architecture, accounting, and small business management – clear candidates for e-learning (2001, p. 125).

Khan's *technological* dimension addresses the need for the most appropriate Learning Management System (LMS), designed to manage multiple content delivery methods, and the most suitable LCMS (learning content management system), designed to catalogue content itself — in the form of online content modules — for the hybrid program. The technological aspect of Khan's Octagonal Model also examines technical requirements such as server capacity and access, security, and additional hardware, software and infrastructure issues (Singh, 2003). Boettcher and Kumar (2000) emphasize that the digital infrastructure integral to hybrid learning must be designed, planned, built, maintained, and staffed, while Khan himself notes the importance of open, published standards, reusability of components, serviceability, and sustainability (Khan, 2005).

The *interface design* dimension addresses issues related to the user interface of each aspect of any hybrid-learning program. The essential “usability” of any specific aspect of the program is paramount. Related issues such as content structure, navigation, graphics, and help also fall within this category (for example, how quickly users can find answers to the most frequently asked questions on the course site). Khan refers specifically to the “overall look and feel” of a hybrid program and emphasizes those aspects of the program that

“facilitate access to and understanding of learning spaces” and “make [content] accessible to all potential learners” (2005, pp. 325-329).

The *evaluation* dimension is similarly concerned with the usability of a blended learning program. The program should be capable of evaluating its own effectiveness utilizing survey tools and checklists, as well as evaluating the performance of individual learners. According to Khan, evaluation issues include how hybrid-learning materials are planned, designed, developed, delivered and maintained, how well courses are taught and supported, how well program and institutional level services are provided, how hybrid-learning programs are viewed by stakeholders, and – finally – how well learners learned the materials (2005). Khan emphasizes the difference between evaluating personnel involved in the delivery of a hybrid-learning course with an online component and those involved in offering a course in a traditional, offline, face-to-face format. In hybrid learning it is not just the teacher’s performance that matters.

In traditional face-to-face classes, learners usually evaluate their instructors – which makes sense... However, e-learning at an open, flexible, and distributed e-learning environment is a different paradigm. ... Like the proverb, “it takes a whole village to raise a child,” the learning at a distance is fostered by the instructor and other support staff, including tutor, technical support person, librarian, counselor, and registration staff (p. 382).

Evaluation procedures for hybrid learning environments may also have to be modified to take account of the distinct features of this type of program.

The *management* dimension deals with issues related to the coordination of a hybrid-learning program – especially infrastructure and logistics – that are fundamental to managing multiple channels of content delivery. The management dimension encompasses registration

and notification, as well as the scheduling of various program elements (Singh, 2003). Singh points out that this element of Khan's model is important for the simple reason that delivering a hybrid-learning program involves significantly more work than delivering an entire course via a single delivery method (2003). According to G. Trentin, writing in "Managing the Complexity of E-Learning Systems" (2003), effective management of the various elements of a hybrid learning program involves having a clear notion of how systems accommodate content delivery, technology, human resources and hybrid-learning processes. Hybrid learning is distinct in its requirement for a higher degree of coordination and cooperation between teachers and the school administration.

The *resource support* dimension deals with making different types of resources (offline and online) available to learners, as well as organizing them (Khan, 2005). Khan provides a number of examples of *types* of resource support that might fall within this dimension of the Octagonal Framework. Resource support could exist in the form of a counselor or tutor who is always available in person, even if "availability" constitutes email or an online chat. At the same time, books and periodicals should be organized in a way that makes accessing them as simple and easy as possible for learners – whether they are accessing these materials at a library or through the Internet (Khan, 2005; Singh, 2003).

The *ethical dimension* identifies the ethical issues that need to be addressed when developing a hybrid-learning program. Issues such as equal opportunity, cultural diversity, and nationality should be addressed. It is of the utmost importance, according to Khan, that a hybrid-learning course – at the very minimum – does not offend those who are taking it. Khan emphasizes inclusiveness, and sees hybrid learning as a highly progressive educational model that needs to reflect the progressive social attitudes that lie at its core. At the same

time, Khan stresses the need for uniformity of content, delivery and overall “student experience”.

[Hybrid-]learning programs should be developed to enable all learners to have a similar learning experience for each of the ingredients of the [hybrid] learning program. Alternate choices need to be provided for learners with special needs [and] [t]he different elements of the [program] should...be compatible... (p. 209).

In this sense, the same burdens exist in preparing courses for hybrid delivery as for the regular classroom. The instructor’s responsibility for providing a sensitive and equitable learning environment does not diminish.

Since the following study is concerned, above all, with measuring student satisfaction and student achievement, it seems reasonable to conclude that – while all elements of Khan’s Octagonal Framework remain relevant – special consideration must be given to the *evaluation* element. The *pedagogical* element, concerned principally with how content is delivered, the needs and expectations of the learners, and overall learning goals, will also occupy a prominent role in collating and interpreting data and coming to key conclusions. The *technological*, *resource support*, and *interface* dimensions will be crucial to fully understanding the relationship between the two elements of the course under study: student achievement and student satisfaction. Since this study is of limited scope, involves a small number of participants, and is fairly short in duration, Khan’s *institutional*, *management*, and *ethical* dimensions will likely be of less importance (for the purposes of this study alone) in measuring the results of a hybrid-learning program when compared to that of a traditional offline face-to-face educational program.

2.2 Hybrid Learning – Literature Review

Despite the newfound popularity of hybrid courses, researchers are struggling to keep up with the applications and implications of hybrid learning, though most have agreed on a definition: that hybrid learning mixes or blends traditional offline classroom activities with Internet or computer-based activities. As mentioned previously, Albrecht (2006) defines hybrid learning as “bringing together face-to-face (F2F) classroom instruction with Web-based activity in which classroom time is partially replaced with Web-based work” (p. 2). While the New Jersey Institute of Technology similarly describes hybrid courses as ones, “in which a significant portion (30% or more) of the learning activities have been moved online, and time spent in the classroom is reduced but not eliminated”. Throughout this literature review, it is important to note that the term “hybrid” or “blended” does not follow any rigid guidelines with respect to the time students spent in the classroom versus the time they spent on web-based activities. The flexibility of course delivery modality inherent in hybrid learning allows individual instructors and researchers alike, to select the degree of hybridization that is most appropriate for the course being offered.

Hybrid or blended learning has become an increasingly popular mode of course delivery in recent years, and as of 2006 was used in some form in nearly 4,000 American post-secondary institutes (Albrecht, 2006). Drawing on modes and techniques developed in distance education, hybrid courses have increasingly been created and delivered due to technological developments, the widespread availability of broadband Internet access, diminishing government funding for education, and expanding faculty and institutional interest, to name a few.

This literature review specifically addresses student satisfaction and student achievement levels with respect to the hybrid-learning environment. However at the onset of this research, in order for the researcher to have a broader understanding of the hybrid-learning environment, many other key factors associated with this course delivery format, were reviewed. These included research pertaining to the advantages and disadvantages of hybrid learning for three stakeholders: a) students, b) teachers, instructors, and faculty, and c) institutions. The researcher also reviewed literature pertaining to the benefits and drawbacks for students with respect to engagement, learner control, age and ability. Finally, the challenges and drawbacks for teachers were reviewed, in addition to the advantages for institutions. Following an in-depth review of the hybrid-learning environment, the researcher selected to focus specifically on student satisfaction and student achievement, as these are two areas where the literature available is minimal – especially at the high school level. Thus, due to the specific nature of this research, all of the above-mentioned factors not directly associated with this study have been summarized and presented in table format for reference (refer to Appendix J: Literature Reviewed) and only literature pertaining specifically to student satisfaction and student achievement levels will be considered here in depth.

Although hybrid learning is increasingly viewed as a viable, highly effective method of course delivery, generally positive sentiment has been tempered by expressions of caution (Reasons, 2004). Contradictory articles exist about how effective the web-based learning environment is in meeting student expectations and needs. While some studies report high levels of student satisfaction with this type of course delivery format (Collins, 2000; Fredericksen et al., 2000; Oliver & Omari, 2001), others have reported that students prefer the more traditional offline classroom-based delivery format (Leasure et al., 2000; Shaw &

Pieter, 2000). A growing body of studies indicates that the vast majority of online learners prefer regular face-to-face contact with instructors (a hybrid format) and generally perform better in their courses when this contact occurs (Riffel & Sibley, 2005), compared to performance in exclusively online formats.

Despite the growing use of hybrid learning, there is a scarcity of research to support its effectiveness in enhancing student learning over the traditional offline face-to-face mode of instruction at the secondary school level. The two main factors that were examined in this research include student satisfaction and student achievement in the hybrid classroom as compared to the traditional offline classroom environment.

2.3 Parameters: Databases and Terms

This research was conducted using the University of British Columbia's Library by searching the terms "hybrid learning" and "blended learning" using the Power Search Engine MetaLib. The databases that were specifically utilized using the EBSCO database included ERIC, Academic Search Complete, and Education Research. Searching the terms "hybrid learning", "high school", and "chemistry", yielded 4 results, while searching the terms "blended learning", "high school", and "chemistry" produced zero results. After widening the parameters and using "science" to replace "chemistry", a total of 25 articles were extracted. Expanding the parameters even further, and using just the two terms "hybrid learning" and "high school" produced 40 results, while searching "blended learning" and "high school" produced 12 sources. In order to increase the number of sources on this topic, using the same search engine and searching the terms "virtual learning" and "high school" appeared to be

more fruitful, with a total of 174 results, although the terms “chemistry” and “science” were not included in these searches.

Though an attempt was made to focus on high school contexts, there is currently limited published research on hybrid education in high schools, and even less when looking specifically at “hybrid education”, “high school”, and “chemistry”, with just 4 results from the EBSCO databases. The overwhelming majority of the literature focuses on hybrid or blended learning in “higher learning”, post-secondary, university, or college contexts, including both undergraduate and graduate students.

Other possible search terms related to hybrid learning that were also explored included: virtual learning, virtual learning environment (VLE), e-learning, distance learning, computer-based learning, information and communication technology (ICT), and technology and learning – all of which were searched for relevancy to this review. The total number of articles when using the above-mentioned terms in relation to “student satisfaction” or “student achievement” produced 141 results; narrowing the parameters to include the term “high school” yielded a total of just 8 articles. As all of the articles were assessed for relevance to the current review of the literature, a total of 60 articles were selected for discussion, review, and background information. These articles included not only the specific parameters of “student satisfaction” and “student achievement”, but also the other integral factors identified in hybrid learning, such as its advantages and disadvantages. As research is limited in the area of high school science or chemistry education and hybrid learning, the articles that were selected for review included those at the post-secondary level, as well as all those that yielded results using the search terms mentioned above. In all, the 60 articles that were reviewed were also not limited to those related to science courses specifically – a broad

range of hybrid courses were reviewed. In the end, out of the 60 articles that were reviewed with respect to hybrid learning, 19 studies pertaining specifically to student achievement and student performance and hybrid learning were selected for detailed analysis and review. The results of this review and a discussion of each study appear in Section 2.4 and 2.5. It is important to note that the articles reviewed for this research use either the term “hybrid” or “blended”, and for the purposes of this study both of these terms are equivalent. Therefore, the words “hybrid” and “blended” will be used synonymously throughout this literature review; however, where possible, “hybrid” will be used to facilitate reading of this review.

2.4 Student Satisfaction and Hybrid Learning

Students’ satisfaction has been acknowledged as an important factor in determining the effectiveness of any course. Given that the hybrid course delivery format has only recently gained popularity, it is not surprising that there is a scarcity of published information regarding students’ satisfaction with this course delivery format. However, with the prospect that more hybrid-based formats will be adopted in secondary education, a thorough examination of the satisfaction of students taking this course delivery format is necessary.

Although most research involving distance education has examined the effectiveness of online courses with respect to class grades and test scores, some researchers assert that simply looking at grades is not sufficient to determine the overall effectiveness of a course, as other factors including student satisfaction may have an impact on student achievement (Smith & Dillon, 1999). A widely accepted definition of satisfaction is the “fulfillment of one's wishes, expectations, or needs, or the pleasure derived from this” (Lent et al., 2007, p. 87). This definition will be used throughout this review, however specific typology related to

student satisfaction and course delivery format will be discussed as articles are reviewed.

Even though student satisfaction is not necessarily related to student achievement (Moore & Kearsley, 2005), satisfaction appears to be an essential constituent for the effective completion of a course (Chang & Fisher, 2003). Additionally, satisfaction is conducive to motivation, which is necessary for student success (Bollinger & Martindale, 2004). In contrast, studies show that students in distance education courses are likely to be dissatisfied and frustrated with the following factors: (a) unclear expectations from instructors, (b) tight timelines, (c) workload, (d) poor software interface, (e) slow access, and (f) no synchronous communication (Gaddis, Napierkowski, Guzman & Muth, 2000). Student satisfaction is also likely to determine whether the student enrolls in future courses using the same delivery format (Arbaugh, 2000). In distance education settings, satisfied students learn more easily, are less likely to drop out of class for non-academic reasons, are more likely to take additional distance courses, and to recommend the course to others (Arbaugh, 2004). It appears that the degree of student satisfaction and likelihood of subsequent enrollment in online courses depend, in part, on how well the courses are planned and taught (DeBourgh, 2003). As mentioned at the onset of this literature review, the majority of these findings are related specifically to post-secondary courses and adult education. Further, these results are also specific to online education, rather than the hybrid variant, and include courses from a wide variety of disciplines. Thus, a review of this literature, although broad, will provide a perspective on the research undertaken in this study. More specifically, information gained from this review will be used to gain a deeper level of understanding of student satisfaction and course delivery format, which influenced the development of the research survey instrument utilized for this study.

Contradictory articles exist about how effective the hybrid-learning environment is in meeting student expectations and needs. While some studies report high levels of student satisfaction with this type of course delivery format (Behrman, 2003; Buzzetto-More, N. A., & Sweat-Guy, R., 2008; Dziuban, Moskal, & Brophy, 2007; Lin, 2008; So & Brush, 2008; Young & Duhaney, 2008), others report that students prefer the more traditional offline classroom-based delivery format (Johnson, Aragon, Shaik, & Palma-Rivas, 2000; Leasure et al., 2000). Several published studies examine relationships between student characteristics and satisfaction with the web-based learning environment. One factor analyzed is the relationship between age of the student and satisfaction with web-based learning. Although younger students are generally considered to be more at ease with online technology (Karuppan, 2001), one study reports that younger students were the least satisfied with web-based learning (Fredericksen et al., 2000). Conversely, other studies have been unsuccessful in establishing a relationship between students' age and satisfaction with the web-based learning environment (Hong, 2002; Jiang & Ting, 1999). Therefore, additional studies are necessary to determine whether age is a factor in determining student satisfaction, and the research undertaken in the present study will add to the limited literature that is currently available in this regard.

Young and Duhaney (2008), So and Brush (2008), and Lin (2008) among others, have found that hybrid learning typically generates significantly higher levels of student satisfaction. Ultimately, student satisfaction levels are of crucial importance in gauging the success and sustainability of hybrid learning programs and their place in the future of education. Young and Duhaney (2008) for example, examine student perceptions of hybrid learning at a private US college, reporting that students were satisfied with hybrid courses on

the basis of a number of factors, including levels of faculty contact, active learning, prompt feedback, encouragement of cooperation among students, and communication of expectations. The sample was comprised of 150 students in the Business Department of the college who took at least one hybrid course. At the time of the survey, the department had a total enrollment of 1000 students. The data used in this study were obtained qualitatively through the use of a questionnaire designed to capture students' perceptions of the hybrid approach. The questionnaire consisted of 18 statements intended to reflect student feelings about hybrid learning and to ultimately categorize overall satisfaction with the hybrid-learning methodology. The 18 statements were categorized as follows: student/faculty contact, active learning, prompt feedback, communicates high expectations, respect for diverse talents and ways of learning, encourages cooperation among students, and a miscellaneous category of overall satisfaction of the hybrid methodology.

Although the students expressed satisfaction with the hybrid courses on the basis of active learning, prompt feedback, encouragement of cooperation among students, and communication of highest expectations, using the hybrid format, their levels of overall satisfaction were not especially dramatic (Young & Duhaney, 2008). The authors conclude that while many students embrace new technologies and course delivery methods, others are still reluctant to abandon traditional offline methods of instruction. Interestingly, participants under age 35 were more concerned about levels of contact between faculty and students than older students. While Young and Duhaney's study is limited in scope, in that it was limited to one group of students in a private university, it suggests that students may not be as eager to adopt new course delivery methods as hybrid learning theorists suggest, and that – somewhat counter-intuitively – older students may be more comfortable with new models of content

delivery than younger, ostensibly more “technologically savvy” students. Inevitably, this study raises questions about the speed with which hybrid learning programs are being introduced and the assumptions at the heart of these programs. It must be emphasized, however, that overall, students were satisfied with the nature of the hybrid learning programs they were offered.

Young and Duhaney’s finding that students are generally satisfied with hybrid courses have been confirmed to some extent by other studies of student satisfaction levels with regard to hybrid learning. So and Brush (2008) for example, set out to measure the relationship between students’ 1) perceived levels of collaborative learning, 2) social presence, described by the authors as the feeling of connectedness and belonging, and 3) levels of overall satisfaction within the hybrid learning environment. The study was relatively small, involving only 48 participants – graduate students who took a hybrid course in health education and worked collaboratively on a project to develop an ambitious HIV-AIDS prevention plan. Data used in the study were both quantitative and qualitative in nature, collected through a Student Perception Questionnaire as well as detailed first-person interviews. The questionnaire/survey consisted of four sections and 56 items, and was designed to measure students’ perceived levels of collaborative learning, social presence, and overall satisfaction. Examples of the statements from the survey included: “This course was a useful learning experience”, “Collaborative learning in my group was effective”, “Using computer-mediated communication is a pleasant experience” (So and Brush, 2008). The interview questions were open-ended, to allow the researcher to explore concerns that the participants had. Some of the questions included: “What were the major differences of collaboration with classmates between traditional offline and distance courses?” “How

important was collaboration with classmates to your satisfaction with this course?” After all of the data was gathered for this study, So and Brush analyzed the relationship between the three variables noted above and came to conclusions that echo those of Young and Duhaney. The quantitative data suggested that student perceptions of collaborative learning within the hybrid learning environment have “statistically positive” relationships with perceptions of social presence and satisfaction – which means, in essence, that those students tended, on the whole, to be much more satisfied with their hybrid course than those who perceived low levels of collaborative learning in the hybrid format. Concurrently, students who perceived high levels of collaborative learning also perceived high levels of social presence within hybrid learning environments. While So and Brush identify a positive relationship between social presence and overall satisfaction, the relationship was “not statistically significant”. This suggests that it is not the method of course delivery (hybrid vs. traditional offline) that matters most; it is the extent to which hybrid models are designed to include the collaborative and social features often found in traditional offline classrooms.

According to this study, perceived communication levels with instructors and peers do appear to affect how satisfied a student is with a given course. At the same time, the qualitative data gleaned from the face-to-face student interviews strongly suggest that student perceptions of collaborative learning, social presence, and satisfaction are intimately connected with course structure and levels of emotional support – as well as the dominant medium of communication. Overall, however, So and Brush’s study, like Young and Duhaney’s study, seems to suggest that hybrid learning, though reliant on new technologies that can foster greater levels of interaction between teachers and students (and between students themselves), must not neglect personal elements of traditional offline teaching

methods that have proven themselves in the past. Student perception of levels of collaboration, feedback, and “presence” are of crucial importance to how they feel about hybrid learning. While technology *can* promote interaction, the studies suggest that the role of face-to-face contact within the hybrid-learning environment cannot be neglected. Therefore, as found in the previous study, communication with the instructor and with other students in the classroom – whether online or face-to-face – does seem to be a factor in how satisfied a student is in a class.

Alonso and Norman’s “Forms of control and interaction as determinants of lecture effectiveness in the electronic classroom” (1996) is an older, but still valuable study that does not explore satisfaction directly, choosing instead to focus principally on levels of student achievement within the hybrid learning environment. The connection between satisfaction and achievement is not necessarily a given, and it is important for the future of hybrid learning to demonstrate conclusively that higher levels of student satisfaction do indeed translate into better grades. Alonso and Norman’s study examines two crucial variables: levels of “learner control” within the hybrid environment and levels of “complex interaction” between teachers and students and between students themselves. As mentioned by the authors, there are several ways to interact with the computer and with the environment (Alonso & Norman, 1996). In this experiment there were two levels of control: (1) Learner Control where the student had active control of the lesson displayed on his/her computer, and (2) Instructor Control where the teacher had an active role and the student was a passive observer. Learner control refers to active exploration and the opportunity for the student to move through the lesson at his/her own pace. The term “forms of interaction” is used by the authors to describe how students interacted with the computer. Descriptions include no

interaction, simple interaction, or complex interaction with the computer. Both of the above variables mentioned above, “levels of control” and “forms of interaction” are concerned with how the student interacts with the system. The data gathered were both quantitative and qualitative, obtained through the use of a post-lecture quiz and a more comprehensive and subjective questionnaire. Students were measured on test performance, responses to the questionnaire, and the number of simulations. These measures were related back to each subject’s test performance and their subjective reactions on the questionnaires. Questions included those related to students’ grade point average, SAT scores, and learning style preference (such as active or passive). The researchers postulated that students would achieve higher marks based on the results of related studies that stressed “active exploration” and “hands-on” learning – and indeed, overall marks *were* higher for students within the hybrid learning environment in comparison to students who were passive observers of the lesson. Additionally, students who were categorized as active learners rather than passive learners showed higher scores for (a) interest in the lecture, (b) enjoyment of the lecture, (c) ease of lecture content, and (d) understanding of the lecture. In regards to control, students were more satisfied in learner controlled situations rather than instructor-controlled situations. Therefore, how well a student performs on assessments in a particular course may well be related to how satisfied he/she is with the class, and as with the present study, this will be examined in more detail. Finally, one of the advantages of an electronic classroom is the ability to tailor each student’s learning environment. As found by Alonso and Norman (1996), some learners prefer to actively move about, while others are more passive learners. This study shows that in general, active learners found the lesson to be significantly more interesting, enjoyable, easy, and comprehensible than passive learners did. In addition, the

active learners in the learner-controlled environment felt that they had more control, and thus were more satisfied with the course than subjects in other conditions.

In another study examining student satisfaction with the hybrid-learning environment, Behrman (2003) discovered a connection between student satisfaction and personal choice, finding that students were satisfied with a hybrid high school biology course where they could use human and Internet resources, rather than just reading a textbook. Here students were able to choose their own resources and consult members of the community to learn more about biology (p.1). In this study students were also introduced to a multi-textual, problem solving approach to content literacy. The above-mentioned study followed an observational case study design that allowed the researcher to focus upon content literacy activities within an issues-oriented, community-focused high school biology class. The researcher observed classroom events and visits to workplace sites, interviewed four students twice each, interviewed the teacher, reviewed a survey of all students at the end of the course, and reviewed students' written work products, including project reports. Behrman reports a common theme among the students that he interviewed. For example, all students reported high levels of satisfaction with the hybrid course delivery format and felt that they learned more in the hybrid format than in the traditional offline classroom format utilizing lectures and textbooks (2003). The two main findings the author reported were: (1) that satisfaction with the hybrid course format was dependent upon the ability to communicate orally with the teacher and with other students, and (2) that students were more satisfied with the course when they could use the Internet rather than print sources related to course topics (Behrman, 2003). Results from the study indicate that given freedom of choice, students gravitate toward oral and digital forms of text. Findings from this study were based on an

observational case study design where the researcher observed classroom activities, interviewed students, analyzed survey responses, and viewed written student work. Based on this study, the author suggests that students are more satisfied with their course when provided with freedom to choose “how” and “what” they want to learn; access to varying course materials is the key to providing this (Behrman, 2003).

Buzzetto-More’s 2008 study, “Incorporating the Hybrid Learning Model into Minority Education at a Historically Black University”, presents the findings of a study examining student perceptions of hybrid business courses at a historically black university in the eastern United States. The authors were especially interested in the question of whether findings related to student satisfaction and achievement within the hybrid learning framework were as applicable to a specific minority group – African-American college students – as they seemed to be to all other groups of students. The study focuses on 178 students who had completed either a business communications or business ethics course using the WebCT course management system and attendant hybrid-learning features including PowerPoint lecture notes, an online glossary of key terminology and definitions indexed alphabetically and by study unit, links to websites, paper-based handouts, online self-assessments, paper-based and online quizzes, individual e-mail boxes and online discussion forums.

The research was undertaken over a course of four semesters of study, and the data – principally quantitative – were collected through an online survey comprised of a Likert scale, multiple choice questions, and subjective questions requiring extended answers. Examples of statements on the satisfaction survey administered include, “I was satisfied with

the overall WebCT portion of the course”, and “I was satisfied with the WebCT portion of the course in regards to the quality of my learning experience”. With respect to the subjective questions that were asked of participants, examples included: “Describe areas of the WebCT hybrid course that were unsatisfactory” and “Would you take a fully online course with no face-to-face interaction?” Data from the survey were analyzed using SPSS, and responses to the subjective questions were analyzed for commonalities. The results suggest, perhaps more clearly than other studies, that the hybrid learning experience is associated with greater levels of satisfaction (92%) among students than traditional offline course delivery methods. Students considered the WebCT and online components of their courses “enjoyable” (89.3%) and “motivating” (70.8%), and were overwhelmingly interested in taking hybrid courses in the future; however, approximately 53% of participants indicated that the hybrid experience had led them to consider taking *fully-online* courses as opposed to hybrid courses. The authors suggest that this is indicative of the larger literature as expressed by Berube, Murray, and Schultz (1999), who argue that there exists a greater acceptance of the online mode of instruction as a complement to learning (Buzetto-More, 2008).

The findings of the above study are generally in accord with those of other major studies in terms of the strong correlation between hybrid learning and student satisfaction; student enthusiasm for fully-online courses seems to contradict – somewhat – the findings of Young and Duhaney, who report concerns among younger hybrid course participants related to a lack of student-teacher and student-student interaction. The authors do not provide specifics about whether the hybrid learning environment was correlated with better student grades, only noting that female participants outperformed male participants – characteristic (the authors note) of most black universities. Therefore, this study adds to the literature

showing that students, irrespective of race, tend generally to be more satisfied with hybrid courses than the traditional offline course delivery format.

Dziuban, Moskal, and Brophy's "Student Satisfaction with Asynchronous Learning" (2007) is another valuable piece that again focuses principally on student satisfaction levels within the hybrid learning environment – analyzing the *specific variables* that tend to either enhance or decrease satisfaction. The paper is not a quantitative or qualitative study per se, but rather a broadly descriptive and analytical work (otherwise referred to as a meta-analysis) that references many other studies and attempts to come to conclusions about today's students: what, in essence, "makes them tick" when it comes to hybrid learning. Paying particularly close attention to *asynchronous* learning – or learning that *does not* involve "real-time" feedback and interaction – the authors explore the impact of media culture, digital, personal, and mobile technologies, and student learning preferences, pedagogy, complexities of measurement, and the so-called "digital generation". Interestingly, the authors show as much interest in dissatisfied students as they do in satisfied students, wanting to better understand the factors behind their dissatisfaction. The authors postulate that some students may be dissatisfied by the very features of the hybrid-learning environment that satisfy most students.

The authors conclude, like the majority of the studies presented above, that "students express satisfaction and *experience success* when they are involved in cohort, team-based learning experiences and have extensive access to faculty" (p. 90) within the hybrid learning environment. The authors describe and assess the results of a pilot study attempting to identify "underlying dimensions" of student satisfaction with online learning. The results of

the pilot study are interesting in that they support other studies' findings that students tend to find online courses "enjoyable", "better for learning" and especially, convenient. The pilot study concludes that a large percentage of students tend to migrate, eventually, from fully online courses to hybrid courses because they find that *some* face-to-face contact is both helpful and reassuring. These results follow the pattern established by other studies, and suggest that the students in the Buzzetto-More study above (those who indicated an enthusiasm for fully-online courses after taking hybrid courses) may not realize how much the elimination of face-to-face interaction will diminish their experience and – likely – push them back in the direction of hybrid learning. Dziuban, Moskal, and Brophy (2007) also present a variety of techniques designed to stimulate student engagement with the hybrid learning experience, concentrating on approaches that take account of student preferences with regard to the use of new technologies. For instance, in order to stimulate student interest in the WebCT portion of the course, the instructor asks students to log in to the course website, and list their favourite movies and songs. The instructor then incorporates these movies and songs in the lessons. The authors mention that frequently students in the class know the lyrics and lines from the songs and the movies, so that it is easy to connect course content to what is already familiar (Dzubian et al., 2007). Additionally, the instructor finds ways to incorporate forms of popular digital media such as Facebook, YouTube, or computer games into lessons, suggesting that these applications are far more engaging than academic applications of technology. The authors indicate that students are more satisfied with hybrid courses when they are engaged in the technological aspects of the course, and when they are able to make choices about what they learn. Therefore this study adds to the literature in that face-to-face communication with the instructor, as well as the option of

exercising individual student preferences on “how” and “what” is learned, largely determines whether a student is satisfied with a given course.

Johnson, Aragon, Shaik, and Palma-Rivas’ 2000 paper, “Comparative Analysis of Learner Satisfaction and Learning Outcomes in Online and Face-to-Face Learning Environments” is an empirical study that compares an online graduate level instructional design course for human resource development professionals, with a course offered in traditional offline (face-to-face) format. Both courses were taught by the same instructor and relied on exactly the same course material; each also involved 19 student participants. Data collected were principally qualitative and obtained using various questionnaires and assessment forms, as well as student records. Like other studies, including those presented above, the study looked closely at student satisfaction levels using student ratings of instructor and course quality and – crucially – an assessment of course interaction, structure, and levels of support. Yet Johnson et al go further, and gather data related to grades and self-assessment, which are important if hybrid learning is to emerge and establish itself not only as a more *enjoyable* experience, but one that produces better achievement levels for students. Interestingly, this study again demonstrates the importance of student perceptions of interaction and support when it comes to overall satisfaction with the online aspects of learning. Students who took a course in the traditional offline face-to-face format expressed slightly more positive levels of satisfaction with their instructor and the overall quality of the course itself than students who took the entirely online course — which involved no face-to-face interaction. There was *no* notable difference between the two formats when it came to levels of student achievement.

In many ways, this study validates the hybrid-learning approach while underscoring the weaknesses inherent in both online learning and conventional teaching. While students expressed slightly greater levels of satisfaction with the physical experience of the face-to-face environment, the fact that the online course produced comparable levels of achievement for students is evidence that the convenience and technology-driven essence of online learning is no barrier to academic success. In essence, the face-to-face learners gained value from physical interaction, and this was ultimately reflected in their satisfaction – not achievement – levels, a finding confirmed by a number of the studies presented above. Once again, this is an aspect of the hybrid-learning environment that cannot be neglected. Students also demand and appreciate convenience, and levels of student achievement in online course results verify the validity of online learning as an academic option. Ultimately, the study discussed above supports some of the philosophical assumptions at the heart of hybrid learning: that the approach is ultimately the “best of both worlds”, combining technology, independence, and convenience with the reassurance and support of the face-to-face experience. Student satisfaction then, as is discussed by Johnson et al. (2000), is largely based on a combination of conventional course components such as teacher-student interaction and collaborative peer work, as well as online aspects, including student-directed pace of learning, educational options, and convenience.

Qiuyun Lin’s “Student View of Hybrid Learning: An Exploratory Study” (2008) is valuable for a number of reasons – not least its extended time frame and its focus on adult students. Lin’s one-year case study examines hybrid learning in two elementary teacher education courses, which integrated the Blackboard Learning Management System (LMS) into the online portion of the coursework. The study relies on feedback from 51 teaching

candidates taking two hybrid courses; surveys collected from the teachers (Student Technology Background Questionnaire and Hybrid Course Questionnaire) yielded both quantitative and qualitative data. Survey items based on a Likert scale include: “online assignments were helpful in understanding the course content”, “the connections between what I did online and in class was clear”, and “I was unable to share ideas with other students”. Ultimately, while a majority of study participants (85%) assessed their hybrid learning experience as positive, others (15%) described their experience as negative or extremely challenging, expressing discomfort with fewer face-to-face meetings and a belief that they were working less hard, and learning less than the students in the face-to-face course. In some ways, Lin’s study highlights possible difficulties faced by slightly older students in adapting to online presentation methods with which they do not necessarily have previous experience. On the other hand, virtually all students appreciated the convenience of the online component of their learning experience, a result supported by the findings of other studies. In essence, the results of Lin’s study suggest that while most study participants were satisfied with their hybrid learning experience – particularly the model’s multiple modes of content delivery, the blend of synchronous and asynchronous interaction – they see room for improvement in course structure. A summary of the findings from each of the studies with regards to student satisfaction can be viewed in Table 1.

Table 1

Student Satisfaction Studies and Hybrid Courses: A Review of Eight Studies from 1996 to 2008 based on the key search terms “hybrid learning” and “student satisfaction”

Author/Date	Research Methodology	Satisfaction found in Hybrid Courses under Investigation: Yes/No	Findings With Respect To Students' Overall Satisfaction with Course Delivery Format
Young & Duhaney (2008)	Survey design	Yes	Students were satisfied with hybrid courses on the basis of a number of factors including levels of faculty contact, active learning, prompt feedback, encouragement of cooperation among students, and communication of expectations.
So & Brush (2008)	Survey design + Qualitative observations	Yes	Identified a positive relationship between social presence and overall satisfaction, although the relationship was “not statistically significant.” Qualitative data from the face-to-face student interviews strongly suggested that student perceptions of collaborative learning, social presence, and satisfaction were intimately connected with course structure and levels of emotional support – as well as the dominant medium of communication.
Alonso & Norman (1996)	Survey design + Qualitative observations	Yes (student satisfaction dependent on student achievement levels).	Satisfaction correlated with achievement. If students achieve higher marks, satisfaction with course delivery style will also increase. In their study, overall marks <i>were</i> higher for students within the hybrid-learning environment, which translated to higher satisfaction as indicated in the satisfaction survey.
Behrman (2003)	Observational case-study	Yes	Found a connection between student satisfaction and personal choice, finding that students were satisfied

Author/Date	Research Methodology	Satisfaction found in Hybrid Courses under Investigation: Yes/No	Findings With Respect To Students' Overall Satisfaction with Course Delivery Format
			with hybrid high school biology course where they could use human and Internet resources, rather than just reading a textbook.
Buzzetto-More (2008)	Survey design	Yes	The hybrid learning experience produced greater levels of satisfaction (92%) among students than traditional offline course delivery methods. Students considered the WebCT and online components of their courses “enjoyable” (89.3%) and “motivating” (70.8%), and were overwhelmingly interested in taking hybrid courses in the future.
Dziuban, Moskal, & Brophy (2007)	Meta-analysis + Questionnaire	Yes	A large percentage of students tend to migrate, eventually, from fully online courses to hybrid courses because they find that <i>some</i> face-to-face contact is both helpful and reassuring.
Johnson, Aragon, Shaik, & Palma-Rivas' (2000)	Questionnaire + Qualitative observations	No	Students who took a course in the traditional offline, face-to-face format expressed slightly more positive levels of satisfaction with their instructor and the overall quality of the course itself than students who took the entirely online course – which involved no face-to-face interaction. There was <i>not</i> a notable difference between the two formats when it came to levels of student achievement.
Lin (2008)	Survey design + Qualitative observations	Yes	While a majority of study participants (85%) assessed their hybrid learning experience as positive, others (15%) described their experience as either negative

Author/Date	Research Methodology	Satisfaction found in Hybrid Courses under Investigation: Yes/No	Findings With Respect To Students' Overall Satisfaction with Course Delivery Format
			or extremely challenging, expressing discomfort with fewer face-to-face meetings and expressing a belief that they were working less hard, and learning less, than the students in the face-to-face course.

The hybrid learning form of course delivery provides a mix between what I refer to as traditional offline classroom components (e.g. face-to-face interaction) and purely online delivery. The studies included in this review were those that included the search terms, and that involved a comparative methodology between traditional offline course formats and web-based formats. Additionally, the selected studies that were reviewed included descriptive analysis of different ways of measuring student satisfaction with course delivery format – a framework from which the student satisfaction survey (refer to Appendix G: Post Course Survey) was developed for this research. Upon review, these studies suggest that trade-offs continue to exist in hybrid learning environments, but that hybrid learning may close some gaps between traditional offline and purely online delivery. For instance, of the eight studies discussed in depth here, seven of these demonstrated that hybrid-learning students had more positive collaborative learning experiences and had more positive perceptions of their own learning (active vs. passive) than in fully online classes (Young & Duhaney, 2008; So & Brush, 2008; Alonso & Norman, 1996; Dzubian, Moskal & Brophy, 2007; Johnson, Aragon, Shaik, & Palma-Rivas, 2000; Lin, 2008). High student satisfaction with the hybrid course delivery format in comparison to the traditional offline format and the

fully online format was also attributed to prompt instructor feedback utilizing web-based technology (Young & Duhaney, 2008; So & Brush, 2008).

The review from this section on student satisfaction and hybrid learning suggests that this course delivery format is gaining popularity when compared to the traditional offline and completely online course formats. Furthermore, perceived deficiencies of the hybrid course format are partially offset by positive perceptions of students enrolled in hybrid courses. For instance, students enrolled in hybrid courses were considerably more pleased with the availability of the instructor to answer questions and the promptness with which they received feedback outside of class when compared to their exclusively online counterparts (Young & Duhaney, 2008; So & Brush, 2008). Thus, the incorporation of an online learning environment within a classroom setting is likely to combine the positive aspects of both types of course delivery methods which include face-to-face interactions with the instructor and other students, as well as the flexibility inherent in online course delivery.

Although all of the studies described above involved post-secondary institutions, this review of student satisfaction with course delivery formats will guide my own research on student satisfaction with the hybrid course delivery format compared to the traditional offline course delivery format. It will also add to the limited research that currently exists with respect to high school students' satisfaction with course delivery format. What has also been revealed by this review, as mentioned above, is the importance of a carefully constructed survey instrument that measures satisfaction. My typology describing satisfaction, as informed by this review on student satisfaction, will be based on the following 4 constructs:

1) student perceptions of the course, 2) access to course materials, 3) communication levels with the instructor and peers, and 4) overall course grades.

2.5 Student Achievement Levels and Hybrid Learning

Achievement or performance (both terms will be used synonymously in this review, as the studies mentioned below utilize both terms to measure learning through quantitative means) is often measured quantitatively – by test and quiz scores, assignment marks, and overall course grades. From my review of the 11 studies discussed below, it appears that student achievement levels generally tend to be greater in hybrid courses when compared to traditional offline courses and completely online courses. For instance, of the 11 studies discussed below, 7 of these report higher student achievement levels utilizing the hybrid course delivery format compared to their traditional offline and/or online counterparts. Table 2 provides an overview of the studies reviewed, comparing the different course delivery formats with respect to student achievement levels. Following this brief review, results from each study are discussed in greater detail.

Table 2

Student Achievement Studies and Hybrid Courses: A Review of Eleven Studies from 2004 to 2009 based on the key search terms “hybrid learning” and “student achievement”

Author / Date	Course Delivery Formats Compared	Findings With Respect To Students’ Overall Achievement Levels
Riffell & Sibley (2005)	Hybrid vs. Traditional offline	Hybrid > Traditional offline
Gutierrez & Russo (2005)	Hybrid vs. Traditional offline vs. Online	Hybrid > Traditional offline > Online
Chandra & Lloyd (2008)	Hybrid vs. Traditional offline	Hybrid Males > Hybrid Females

Author / Date	Course Delivery Formats Compared	Findings With Respect To Students' Overall Achievement Levels
		Traditional offline Females > Traditional offline Males
Vilkoniene (2009)	Hybrid vs. Traditional offline	Hybrid > Traditional offline
Waite (2007)	Hybrid vs. Traditional offline	Hybrid > Traditional offline
Condie & Livingston (2007)	Hybrid vs. Online	Hybrid > Online
Lee C., Yeh, D., Kung, R., & Hsu, C. (2007)	Hybrid vs. Online	Hybrid > Online
Baki & Guveli (2008)	Hybrid vs. Traditional offline	Hybrid = Traditional offline
Limniou M., Papadopoulos, N., & Whitehead, C (2009)	Hybrid vs. Online	Hybrid = Online
Olapiriyakul & Scher (2006)	Hybrid vs. Online	Hybrid = Online
Gutierrez (2004)	Hybrid vs. Traditional offline	Hybrid > Traditional offline

Note: symbol > indicates that the item on the left had better results than that on the right. The symbol = indicates no significant difference in results.

Riffell and Sibley (2005) developed a hybrid course to deliver an introductory environmental biology course to university students. The hybrid course included online assignments and meetings in a lecture hall that focused on active learning assignments. After a short lecture by the instructor, students were assigned a task to complete. Students worked in informal groups and typically partnered with neighbor(s). Students could ask questions of their peers and the instructor during the active learning session. Each student handed in his/her own answer to be graded and a brief summary lecture followed each activity. In order to measure and evaluate the effectiveness of the web-based component of the course, the hybrid course was taught simultaneously with a traditional offline course in which passive lectures were used to cover the course material found in the online assignments. The researchers administered a survey at the beginning and at the end of each course to collect

data about the demographic composition of the students, self-reported measures of effort, and student perceptions of the course. When the researchers evaluated the grades in both courses, they found that there was an increase in students' overall achievement levels in the hybrid course when compared with the same course delivered utilizing traditional offline means. Regardless of class standing, students in the hybrid section scored better on the course assessment tests than their traditional offline counterparts. The hybrid course also provided students with more control over when, where, and how they learned compared to students in the regular course. In student survey comments, students in the hybrid section reported high quality interaction with their instructor. The researchers asserted that the level of student engagement with the material and interaction with the instructor, facilitated by the hybrid format, had a direct effect on student achievement. They concluded that the hybrid course format was instrumental in increasing student achievement levels, and therefore, student achievement levels were greater in the hybrid course format than in the traditional offline course delivery format.

In a study that yields similar findings, Gutierrez and Russo (2005) examine three ten-week introductory business courses at the community college level, one traditional offline, one online, and one hybrid. The courses were otherwise identical in terms of their content. The sample consisted of a total of 51 students, 20 of whom were in the traditional offline course, 13 from the online course, and 18 from the hybrid course. Their findings were gleaned from both a comprehensive survey of students and their grades at the end of the respective courses. The survey instrument developed by the researchers asked students to rate the following areas on a scale of one to ten as they pertained to the course: 1) the instructor's computer skills, 2) instructor's level of communication and feedback during the course, 3)

how well the course was organized, 4) how much students thought they learned in the course, 5) the academic standards in the class, and 6) the students' overall learning experience in the class. Mean scores were then calculated for each rating and all scores were converted to a percentage grade based on 100 percent. Students were also asked how relevant they thought course assignments, lectures and exams were in relation to the course. Finally, students were also asked what type of course would they rather be enrolled in given a choice: traditional offline, online, or hybrid courses. Upon examination of the survey results with respect to how students rated the course and the instructor, the researchers found that students enrolled in the traditional offline class gave the highest ratings to all six areas that they were asked to evaluate. The online and hybrid courses received similar ratings in four of the six areas. The highest ratings by all three groups were in two categories, how well the course was organized and the instructor's level of communication with the students during the duration of the semester. The researchers also examined course grades of all the students in all three classes. The final course grades indicated that the hybrid students performed slightly better than the traditional offline or online students. The mean score for the hybrid group was 83.75%, 82.76% for the traditional offline group and 82% for the online group. When examining the number of "A" grades assigned to students at the end of the course, only 7% of the students enrolled in the online course received an "A" compared to 23% of the traditional offline students and 35% of those enrolled in the hybrid course. While the hybrid class performed better than the other two sections, students gave it some of the lowest ratings in several areas including course organization, academic standards, and overall student learning experience. The traditional offline course on the other hand, received the highest ratings in all areas. Only one area, the instructor's level of communication received a 90 percent or higher rating. In

spite of receiving lower ratings than the traditional offline course, once students had an opportunity to experience a course delivered using the hybrid model, 73 percent of them selected the hybrid model as their preference over traditional offline or online courses.

In light of these results, it is necessary not to generalize these findings in regards to the three different course delivery formats that were investigated. First, the sample size of 51 students was small. Second, this study involved only one course from one discipline (Business), which may be problematic as not all courses are compatible with the hybrid course delivery format. Also, other factors that were not investigated in this study may help to explain why the hybrid students performed better than the traditional offline and online students.

In addition to the studies of Riffell and Sibley (2005) and Gutierrez and Russo (2005), Chandra and Lloyd (2008) also performed a comparative study based on course delivery format. Moreover, these researchers also examine whether there is a difference in student achievement based on gender. The study involved grade 10 science students in two cohorts over a 2-year period. Both groups undertook the same semester program with respect to subject content, however, one group studied in a hybrid environment, while the second group studied in a conventional offline classroom setting. The first cohort had a sample size of 210 students, and the second included 232 students. Both groups were of comparable size, gender balance, and ethnic diversity. In term 1, both cohorts studied a chemistry unit. They were instructed utilizing traditional offline teaching pedagogy and were assessed in similar ways. In term 2, students studied a unit in physics. Based on prior observations, the researchers suspected that students would generally achieve lower test scores in the physics unit than in the chemistry unit, as it was perceived to be conceptually

more difficult for students to understand. Certain lower-achieving boys were an exception to this as they had, in the past, tended to ‘do better’ in this unit compared to the rest of their cohort. At the end of each unit and each term, all students wrote tests that were developed within the school. Performance data was therefore available for each cohort at the end of each term/unit and made comparisons possible between the two cohorts and the two different instructional formats under investigation. The means from the tests were compared using a paired sample t -test, and further analysis was done with respect to gender differences from the term 1 unit. These results were then compared with the results from the term 2 unit using a paired sample t -test. The boys in the traditional offline group (Cohort 1) obtained a lower mean in the test after the physics unit ($\text{Pre-}M > \text{Post-}M$). This result was reversed for the boys ($\text{Pre-}M < \text{Post-}M$) in the hybrid group (Cohort 2), and the difference between the means for the hybrid group was statistically significant ($p < 0.01$). These results showed that in comparison to the traditional offline group, boys in the hybrid group performed better. The performance of the girls in the traditional offline group (Cohort 1) was similarly compared with the results obtained by the girls in the hybrid group (Cohort 2). For the girls in the traditional offline group, the mean obtained after the completion of the physics unit was lower than the mean from the test done before this unit. This difference was also statistically significant ($p < 0.01$). The difference in the mean for the hybrid group was negative, smaller and not statistically significant. As with the boys, the girls in the hybrid group also performed better in the test on the physics unit. Results from this study indicated that overall, student performance was greater in a hybrid science class than in a traditional offline class.

Further analysis of the results indicated that there was a difference in achievement levels based on gender. For example in this study, girls who had been performing well in the

traditional offline class performed more poorly in the hybrid class, while boys who had been performing poorly in the traditional offline class improved their scores in the hybrid class. Thus, this study suggests that student achievement may be related to course delivery format – with hybrid students performing better than their traditional offline counterparts. This study also alludes to the notion that gender differences may emerge when comparing student achievement levels in the hybrid class and the traditional offline class, as is evident in this study where boys outperformed girls in the hybrid format, but girls outperformed boys in the traditional offline format. Surprisingly, the authors do not provide specific reasons to support the results from this study based on gender differences. Instead, the authors conclude that the use of ICT in courses does improve student performance, however this improvement is not equal, and the impact of ICT is evidenced differently for different groups (Chandra and Lloyd, 2008).

Similar results were described by Vilkoniene (2009), who looked at the application of augmented reality technology (ARTP) in aiding learning in the classroom. The hybrid environment can be created using augmented reality technology (ARTP), i.e., augmenting real objects found in the environment with virtual information found online. Results from the study indicated that students preferred learning environments that combined conventional features (physical classroom and face-to-face classmate/teacher contact) and virtual aspects (i.e., hybrid) in science education. Augmented reality is created by using computer displays that affect the user's senses and provides additional information. Vilkoniene (2009) describes how augmented reality technology is utilized. For example, a virtual view or text is inserted into a student's field of vision and information is received not only visually, but through the other senses such as hearing or touch as well. Thus, the basis of augmented reality is created

by visuals that can be observed using special devices such as stereo glasses. The result of augmented reality technology (ARTP) on students' learning is the direct connection between real and virtual information. Vilkoniene was also interested in analyzing the effect of ARTP on student achievement levels. In all, 110 grade 7 students took part in the study. Students were divided into two groups: the study group that received ARTP instruction, and the control group who received only classroom-based offline instruction. Both groups had similar achievement levels prior to unit of study, and upon completion of the digestive system unit identical assessments were administered to both groups. Analysis of the research data indicates that students in the ARTP cohort group had higher achievement levels when compared to students who did not use ARTP. This study bears similarity to the hybrid-learning studies, as this is a direct example of instruction that is a combination of the traditional offline form of instruction, supplemented by a unit of instruction that is presented to students online.

It seems then, that incorporating online or virtual components in traditional offline face-to-face courses may have a positive impact on student performance when compared to their traditional offline counterparts, as reported by Waite (2007). In his study, Waite (2007) compares the midterm exam grades of students in his hybrid Graphic Communication Technology Course to grades recorded in his traditional offline Graphic Communication Technology Course from previous years. He found that although the average midterm exam grades of students in the hybrid class did not yield significant differences when compared to achievement levels of students in the traditional offline class, the distribution of students who achieved "A" grades was significantly higher in the hybrid group. Waite (2007) attributes these results to the benefits of the online quizzes which supplemented his otherwise

traditional offline classes suggesting that .the online component of his course provides immediate, valuable feedback to his students, which is not possible in his traditional offline classes. Thus, frequent online quizzes helped secondary school students maintain high grades in traditional offline classrooms. The hybrid combination of the traditional offline course delivery format with online components appears to show increased student achievement, although it is unclear from a review of this study whether this success is due to the benefits of the online WebCT component (such as immediacy of the feedback provided), or simply the inclusion of frequent online quizzes, which were missing from the completely traditional offline classes.

Support for mixing face-to-face and online components to improve student achievement is echoed by Condie and Livingston (2007). These researchers investigate the impact of the SCHOLAR program – an e-learning program available to all students in Scotland who are over 16 years of age and who are interested in pursuing technical or vocational training. The SCHOLAR program is an optional online component designed to complement rather than replace traditional offline teaching and learning approaches within schools. This program provides students with a number of online components such as course materials, review problems, self-assessments and an online discussion feature. The independent evaluation of SCHOLAR examines the effect that it had on learning and teaching in the classroom, as well as the ways the program was accessed by students and teachers.

Evaluation of the SCHOLAR program was based in part on student achievement levels in the national certification examinations, comparing the performance levels of those students registered for SCHOLAR with those who were not. “The analysis of performance,

undertaken in collaboration with the Scottish Qualifications Authority (SQA) and including the entire national cohort for each of the 2 years, showed superior performance by SCHOLAR students, although the differences varied across the subjects and the level of examination” (Condie and Livingston, 2007, p. 341). Contrary to these results, when teachers were questioned about whether they thought the SCHOLAR program had produced a positive impact on student learning and achievement, 56% did not believe it had. One possible explanation of this finding may be a lack of knowledge among teachers about student use of the SCHOLAR program outside of class time. Condie and Livingston (2007) also suggest that had teachers been more aware of the impact on the students’ academic results as a result of using SCHOLAR they might have used it more effectively to engage the students more actively in the learning process.

Although this study does not provide a direct connection between students’ increased chances for independent study and improved achievement levels, it may be feasible to propose that the possibility to interact with learning materials presented in different formats at a time that is convenient to the student may have contributed to an increase in confidence and engagement with the material, as well as more depth and knowledge of the subject. The results of the evaluation also indicate that students who made use of the SCHOLAR program used it to individualize and check their own learning in order to identify gaps in their understanding. While the SCHOLAR program appears to have an impact on student achievement levels, findings from this study suggest these gains may have been more significant if teachers had taken a more active role in incorporating and blending their traditional offline teaching methods with SCHOLAR.

In a study that aimed to identify the factors necessary for success in a hybrid class, Lee et al. (2007) find that student achievement levels in hybrid environments (which included face-to-face lessons and portfolio-based technology lessons) were related to the same factors that influence success in traditional offline classrooms. Instructional materials were put on a K-12 digital instruction platform to allow students to navigate through the course online. This study took place over a 3-month period and included 48 junior high math students. Upon completion of the course, the learning portfolios of students (including the number of times they entered the website, the number of times they attended the online class, the number of essays being posted, the number of online discussion entries, the number of hours of reading, the number of pages being read, the progress of reading, and the results of online tests) were gathered as evidence for evaluating the learning results of students. Data collection also included written test results and a questionnaire on student learning attitudes. The data was then statistically analyzed. Interactive factors such as posting essays or discussion comments online were not related to test scores, which the authors suggest is a good reason for hybrid learning to be used as an addition to traditional offline classroom activities rather than a replacement. The factors that were correlated with student achievement were much the same as those in the traditional offline classrooms: time spent reading course material, student attitudes towards learning, and how well students performed in assessments.

In a study comparing the hybrid and traditional offline instructional formats, Baki and Guveli (2008) note that although much research has shown the positive effect of web-based mathematics teaching (WBMT) on student achievement, (as cited in Baki and Guveli, 2008, p. 854), their study found that there was little difference between the test scores of the 9th

grade math students who used WBMT and those who did not, though WBMT students had slightly higher test scores. The purpose of the study was to develop web-based mathematics teaching (WBMT) material for 9th grade students studying the concept of mathematical function, and to evaluate and compare the effectiveness of the WBMT material. The study was conducted during the Fall Term of 2004–2005 for a period of five weeks at a high school in Trabzon, Turkey. Two grade 9 classes with the same number of students were chosen for this study. These two classes were instructed by the same teacher. Students' academic levels in both classes were determined by a pre-assessment test that showed each group was similar with respect to level of mathematical skill upon beginning the course. One of these classes was selected as the control group and the other was the experimental group. While the control group continued their lessons with traditional offline methods, the experimental group was instructed with the addition of web-based mathematics teaching (WBMT) material. Unlike the traditional offline course, the web-based course had a website that included explanations, examples and interactive exercises for the topic of functions. Additionally, students in the experimental group had classes in the computer lab for two hours every week. They practiced using WBMT material in addition to receiving traditional offline lectures on the topic under the direction of the teacher. Thus, students had approximately 10 hours of computer lab sessions over the duration of this study. In addition to this period of time, students in the experimental group could access the WBMT on their own time from home. Following the 5-week study period of both groups, success rates of the control and the experimental groups were compared. The post-achievement test was comprised of 20 multiple-choice questions including all topics covered in the unit of functions in the grade 9 mathematics curriculum. The reliability of the post-achievement test

was determined as $r = 0.62$ and the final scores for both groups were compared with the post-achievement test. Analysis of the data shows a positive effect of WBMT on student learning of mathematical function and on attitudes towards WBMT (Baki et al., 2008). Thus, the results from this study support the use of WBMT material as an alternative course delivery format to traditional offline classes, as student achievement levels between the traditional offline class and the class that received WBMT material did not vary significantly, and students in both groups performed equally well.

This study is important, as WBMT is a variant of the many forms of hybrid learning, and the results from this study demonstrate that not all forms of hybrid learning result in significant improvements in student achievement levels. The authors suggested reasons to explain these results include: students' lack of computer literacy and computer lab conditions, carrying out a unit of instruction in a method that they were not normally accustomed to, problems with consistent Internet access, and a lack of motivating factors such as awarding grades.

Similar to the results from Baki and Guveli's study (2008), but contrary to Condie and Livingston's research (2007), Vilkoniene's study (2009), Gutierrez and Russo's study, and Riffell and Sibley's study (2005), Limniou et al. (2009) find there is little difference in "learning outcomes" between two groups of post-secondary students who participated in preparatory pre-laboratory sessions. One group of students used WebCT and had asynchronous communication only, while the other group had face-to-face instructional time in a computer cluster. In other words, the first group had an online-only version of the course, while the second group studied within a hybrid-learning environment. Limniou et al.

(2009) find that the students from both groups were equally prepared for the lab they later took part in, and both groups had similar achievement scores on their lab assessments.

Supporting Limniou et al.'s (2009) findings, Olapiriyakul and Scher (2006) also find little difference between hybrid and distance courses in terms of student achievement levels, though students' perceptions about the hybrid course were better than in the fully online distance course. Interestingly, these researchers also study how the students learned, finding that most students who took the hybrid course were "active/sensing/sequential/visual learners" who preferred learning visually rather than from oral presentations (p.287). Although hybrid learning did not yield any measurable results in the above-mentioned study with respect to student achievement, the authors conclude that hybrid learning might be a useful instructional tool to address different learning styles (Limniou et al., 2009).

With respect to assessment measures of students in a hybrid course and in a traditional offline course, two studies involving hybrid courses compare two criminology classes and find that overall, students in the hybrid course had higher achievement levels than those enrolled in a traditional offline criminology course (Gutierrez, 2004; Gutierrez D., Wiese, J., Lopez, N., Portello, N. and Beninati, 2004). The comparison however, only included a hybrid and traditional offline course and did not include comparisons with a completely online version of the course. Researchers in the second study however, (Gutierrez et al., 2004) evaluate hybrid courses across three different fields of study: business, accounting and criminal justice.

The findings from this study reveal that only the students enrolled in criminal justice classes preferred hybrid courses over other delivery formats. However, their study fails to compare types of delivery formats other than the hybrid model, and they do not examine

course-learning outcomes. Therefore, due to the limitations of the above two studies, it is important to note that student achievement may vary based on students' individual preferences for specific courses.

While some of the studies described above show that student achievement levels in hybrid courses are equal to and sometimes better than achievement levels in traditional offline courses, the reasons for this difference are sometimes unclear and a host of other factors may be partially responsible for explaining some of these findings, such as student preference for course delivery format based on the course, or individual student learning styles. For example, are hybrid courses mainly taken by students with a preference for visual learning styles? In this case, the results might reflect on the students as much as on the format. In light of this, a word of caution is necessary. In order to have a broader picture of student achievement levels with respect to course delivery styles, research comparing student achievement levels in all three course delivery formats – the hybrid format, the traditional offline format, as well as the online version – is necessary, although not possible in the case of the research being conducted for this thesis. Additionally, it is necessary to have these studies conducted over a range of disciplines, and across a wide range of demographics in order to understand better just how and why student achievement levels vary based on course delivery formats. The section on limitations of the research reviewed (Section 2.6) provides a more detailed look at some of these concerns and issues.

2.6 Limitations of Research Reviewed

It should be noted that findings from studies that include small sample sizes should not be generalized for the overall student body. Additionally, the majority of the studies on

hybrid learning have compared the hybrid, traditional offline, or online version of the same course. This may be problematic because certain courses (such as trades or lab-based courses) may not be compatible with the hybrid model, as this depends on factors such as course content and the subject matter to be taught. With regards to hybrid learning and the satisfaction of students enrolled, other crucial factors may be at work that can provide an explanation as to why the hybrid students were more satisfied with the hybrid format or had higher achievement scores than the traditional offline or online groups. These factors are discussed by Bullen (1999), Barbour and Reeves (2009), and Cook (2008). They offer particularly valuable insights into the limitations of the research associated with web-based course delivery formats.

Bullen (1999) notes a number of problems with research involving web-based courses in post-secondary education, and finds that much of the research that has been conducted is flawed for four central reasons: “(1) Extraneous variables were often not controlled for, (2) researchers failed to use random assignments for subjects to treatment and control groups, (3) the validity and reliability of measurement instruments are suspect, and (4) reactive effects of subjects were not properly controlled for” (Phipps & Merisotis, 1999, cited in Bullen, 1999, p. 103). In addition to too few studies being used to establish the effectiveness of distance education, Phipps and Merisotis contend that the studies that have been conducted have not been scientifically rigorous, rendering the results unreliable. The literature on hybrid learning is similarly scanty, and furthermore, the studies on the effectiveness of hybrid education could be charged with unreliability. Bullen suggests it is very difficult to achieve perfect experimental conditions when studying educational delivery, as students cannot be placed into control and experimental groups, and means to achieve scientific results would

intervene with course delivery and learning itself. Rather, Bullen suggests taking a more subjectivist approach. Indeed, much of the research done on hybrid learning relies on qualitative data, including, for example, reports on students' perceptions of satisfaction and course quality. However, when assessing and comparing student achievement levels based on the hybrid course delivery format, the collection of quantitative data such as exam scores is crucial for any sort of comparative analysis to be conducted.

As research in the area of hybrid education is limited (for example a search using the EBSCO database yielded 106 results when searching the key terms, "hybrid courses" and "education"), much of the research that does exist or that is reviewed, is largely based on distance education studies. For instance, Barbour and Reeve's (2009) report reviews virtual schools and their benefits and limitations. According to Barbour and Reeves, the most accepted definition of a virtual school is an entity approved by a state or governing body that offers courses through distance delivery – most commonly using the Internet. While virtual schools can be classified in different ways, the three common methods of delivery are by independent, asynchronous, or synchronous means. Presently, the vast majority of virtual school students tend to be a select group of academically capable, motivated, independent learners (Barbour & Reeves, 2009). The literature on K-12 learning in virtual schools takes issue with a number of established research precepts: "The benefits associated with virtual schooling are expanding educational access, providing high-quality learning opportunities, improving student outcomes and skills, allowing for educational choice, and achieving administrative efficiency. However, the research to support these conjectures is limited at best" (Barbour & Reeves, 2009, p. 402). These authors argue that this is a problem because K-12 learners have been ignored and that the research has problematically assumed that

young learners think in the same way adults do, resulting in the creation of virtual courses designed for more mature learners, but delivered to children. With respect to hybrid courses, Barbour and Reeves' definition of virtual schools encompasses the synchronous aspects of hybrid delivery as well as the use of online content for instructional means. By no means are the limitations outlined in Barbour and Reeves' review transferable to all hybrid-instructed courses, as the degree of hybridization (i.e., extent of online content vs. face-to-face instructor presence) can largely affect the success of the course. This is evidenced by the various studies that have been reviewed on hybrid courses and student satisfaction and achievement. For instance, Riffell and Sibley's (2005) hybrid course was designed to include daily face-to-face lectures and two online assignments each week. Conversely, Lin's (2008) hybrid courses were designed to include only two face-to-face sessions; all other sessions were online. So and Brush's (2008) hybrid course was comprised of a total of six face-to-face sessions and an online group collaborative project. Thus as can be seen, the degree and form of hybridization varies based on the course designer, and the results from each hybrid format study conducted will also be different. Further, the assertion by the authors that online courses are primarily designed for mature learners rather than children is once again questionable in relation to hybrid-developed courses, as the success of these courses is largely based on a number of factors which are reviewed in Appendix K: An Overview of Literature – Additional Factors. These include course subject matter (Arbaugh, 2005a; El-Gayar & Dennis, 2005; Olapiriyakul & Scher, 2006), course content (El-Gayar et al., 2005), course developer (Power, 2008; Singh, 2003), and course instructor (Burrell-Ihlow, 2009; Fillion, Limayem, Laferrier & Mantha, 2009; Jonnson, 2005) – as well as familiarity and access to technical support (Beldarrain, 2006; Chang & Fisher, 2003).

Cook's (2008) literature review of K-12 virtual learning communities (VLCs) notes the limited availability of research in this area, though interest is quickly increasing. Because VLCs for K-12 are just starting to develop, not much has been published on the topic, though more has been published on VLEs (Virtual Learning Environments) for K-12 and adult learners. Virtual learning communities are learning communities based not on actual geography, but on shared purpose. Through technology, learners can be drawn together from almost anywhere, and they can construct their own formal or informal groups (Glazer, 2001). As such, virtual learning communities are separated by space, but not time, as communication can be facilitated through technology in real time, partially overcoming geographical barriers. Following Sadik (2003) and Downs and Moller (1999), Cook says there is a "need for research to address the young generation of online learners and specifically the topic of socialization at the high school level. The paucity of literature at the K-12 level is largely attributable to the fact that the field is in the early stages of development and as such, concepts are not clearly defined" (Cook 2008, p.10). The author goes on to say that the VLC field is very broad and there is no unity in understanding. Further, the lack of available relevant literature necessitated a reliance on informal, unpublished works dealing with K-12 VLCs.

The literature on hybrid education is similar to Cook's description of VLC research and it is therefore reasonable to extend Cook's assertions about research on VLE's to HLEs (Hybrid Learning Environments). By definition, "A virtual learning environment is defined as a software system designed to support teaching and learning in educational settings" (Martin 2009, p.181). A VLE usually works over the Internet and provides tools such as communication, uploading of content, return of students' work, tracking tools, etc. One can

argue that an HLE is in effect supported by a VLE. Comparing Cook's literature review of VLE's to hybrid education, many similarities are noted. When comparing the online component of VLE's and HLE's, both of these utilize synchronous and asynchronous communication and collaboration opportunities. In both of these environments, students can communicate with each other and teachers using communication tools such as chat and email.

Research on hybrid learning in general is scant, though more has been published in the last two years. As addressed at the outset of this review, much of the research focuses on adult learners in post-secondary hybrid contexts; few studies deal with implications of hybrid education for K-12. Hybrid education also suffers from a lack of clarity around concepts, as the field is new but growing. While online courses have a greater enrollment of students than hybrid courses, it is plausible that hybrid models might have greater potential and provide more benefits in K-12 schools than a fully online delivery model. Innovators in the field of K-12 online learning have made similar observations and comments. For instance, Julie Young, the founder and president of the Florida Virtual School, when asked about her vision for the future of her school and online learning, said: "Within five years, there will be lots of blended models such as students going to school two days a week, and working at home three days a week" (Young 2007, p. 8). Similarly, a recent study commissioned by the North American Council for Online Learning reiterates Young's prediction and states:

The blending of online programs and the classroom setting has been relatively slow to develop in K-12 education. However, emerging models in other countries, such as Singapore and Australia, as well as in higher education, suggest that a large part of the future of education will involve providing content, resources, and instruction both digitally and face-to-face in the same classroom.... This blended approach combines the best

elements of online and face-to-face learning. It is likely to emerge as the predominant model of the future — and to become far more common than either one alone. (Watson, 2008)

Therefore, while there have been important studies in the field of VLC's and HLC's, there is an increasing necessity to add to the current research at the K-12 level. Furthermore, a review of the research at the post-secondary level can help to inform and provide a contextual basis for research at the K-12 level.

2.7 Conclusions

In sum, the hybrid model over the past few years promises to occupy an increasingly important role in K-12 teaching and learning. Further, as its usage in the K-12 system increases, research on its efficacy will be fundamental to educators and course developers who are involved in its planning and delivery. In addition to the published research discussed, this review also relies upon unpublished and informal research (Cook, A., 2008; Delman, C., 2000; Gaddis, B., Napierkowski, H., Guzman, N., & Muth, R., 2000; Hu, W., 2009; Jukes, I., McCain, T., and Kelly F., 2009; Khattab, M., 2009; Lago, M.E., 2000; Nichols, M., 2008; Waite, J. 2007) to provide a broader understanding of the hybrid course delivery format and how it compares to the traditional offline format in terms of student satisfaction and student achievement. As a reiteration, at the commencement of this review, only 60 articles were available on the library database specific to hybrid learning and high school courses. Review of these 60 articles allowed for a greater understanding of the hybrid course delivery format, and from these 60 articles only the articles pertaining specifically to

student satisfaction and student achievement were reviewed and discussed in depth. Research for this review was also drawn from the field of distance learning, e-learning, virtual learning environments, and information and communication technology to complement the research on hybrid learning. The research that I will undertake, comparing student satisfaction and achievement in the traditional offline and hybrid classroom, will add to our current limited understanding of the effects of this course delivery style on adolescents, as is evidenced by the mixed findings presented in this review of the literature, and summarized in Table 2.4 and Table 2.5, respectively. Additionally, gaps such as the lack of any comparative studies on the hybrid course delivery format with the traditional offline course delivery format in high school chemistry courses will add to the research in this respect. Data collected from this study such as the Student Satisfaction Survey (refer to Appendix G: Post Course Survey), will provide information to other researchers and course developers about what traditional offline components work better than hybrid components (and vice versa). Recognizing and implementing these changes could result in increased student satisfaction and performance. Analysis of the Student Satisfaction Survey will also provide data on issues of importance to students in high school chemistry courses, with the two different course delivery formats. This in turn will add to the limited data that is currently available for this specific demographic and course discipline.

3 METHODOLOGY

3.1 Research Questions – An Overview

As previously mentioned, the research questions addressed in this study involve an investigation of whether a difference exists in student satisfaction and achievement based on course delivery format. In doing so, the study seeks to determine if hybrid courses really do offer the “best of both worlds” (Young, 2002, p. 33). Specifically, the study compares feedback from students enrolled in a hybrid Chemistry 12 course with students enrolled in a traditional offline face-to-face course to determine if the hybrid learning environment produces higher achievement levels, a higher perception of course content, a more positive feeling about access to course materials, greater communication levels with the instructor and peers, and satisfaction with course grades. This chapter presents the theoretical constructs with respect to the hybrid course, describes the research design and methodology, the selection of subjects, data sources and instrumentation, validity and reliability issues, and concludes with data analysis and limitations.

3.2 Methodology

According to Badrul Khan’s Octagonal Framework, a number of factors are useful in order to provide a meaningful hybrid-learning environment. Many of these factors are interrelated and interdependent as discussed by Singh (2003). Using the Octagonal Framework as a foundation from which the research methods section was developed, it seems appropriate to discuss these factors and provide examples of how these factors are related to this study. As a review then, the Octagonal Framework is comprised of eight dimensions. These include: institutional, pedagogical, technological, interface design,

evaluation, management, ethics, and resource support (Khan, 2005). Each part of the Octagonal Framework represents a key area that needs to be addressed in order to create a successful hybrid-learning course. It is also imperative to mention that the hybrid course involved in this study was developed based on Badrul Khan's Octagonal Framework (2005). For example the Institutional Dimension addressed assignment of students to one of the two classes. The Pedagogical Dimension was utilized when determining what content would be presented on the course website, and what part of each lesson was presented F2F. The Technological Dimension was necessary in order to ensure accessibility to the server and Internet access. Issues such as, content structure, navigation, and graphics was addressed by the Interface Design dimension. The Evaluation Dimension of the framework was used to determine how useful the hybrid course was in meeting students' learning outcomes. The Management Dimension was used to negotiate the various elements required in order to design the hybrid chemistry course. The Resource Support Dimension was used to ensure that students were able to contact the instructor via email or F2F to address any difficulties with the course. Finally, the Ethical Dimension was used to ensure that equal opportunities, gender equity and cultural diversity needs were addressed when designing the hybrid course. Following is Table 3 outlining the eight dimensions from the Octagonal Framework, and a description of each.

Table 3***Octagonal Framework and Methodology***

Octagonal Framework Dimension	Description and Examples Related to the Development of the Chemistry 12 Hybrid Course Section
Institutional	Issues addressing the organization and administrative aspects of the hybrid course. These include addressing students' needs, and availability of content and infrastructure.
Pedagogical	Issues related to the design and strategy aspect of the hybrid course. This dimension includes selecting the most appropriate delivery method for a given section within a lesson in order to provide content and address learning objectives.
Technological	Once delivery methods involved in the hybrid course have been determined, technological issues such as a server that supports the learning program, access to the server, bandwidth and accessibility, security, and other hardware, software, and infrastructure issues need to be addressed (Singh, 2003).
Interface Design	Issues such as content structure, navigation, and graphics can be addressed in this dimension. For example, in the Chemistry 12 hybrid course, students should be able to easily move from the online environment to the F2F offline environment, and assimilate both equally well.
Evaluation	This dimension involves how usable the hybrid course is. For example, the hybrid course should be designed in a manner that allows for evaluation on how effective the

Octagonal Framework Dimension	Description and Examples Related to the Development of the Chemistry 12 Hybrid Course Section
	course is, as well as have the capability to assess student performance based on this format.
Management	The management dimension addresses issues such as registration and notification, and scheduling of the different elements of the blend (Singh, 2003).
Resource Support	This dimension involves ensuring that different types of resources (offline and online) are available for students. For example, students being able to contact the instructor via email or F2F to address any difficulties with the course.
Ethical	This dimension identifies the ethical issues that need to be addressed when designing a hybrid course. Issues such as equal opportunity, gender equity and cultural diversity need to be addressed.

For this research, data was gathered from two classes: a traditional offline Chemistry 12 class, and a hybrid Chemistry 12 class that met face-to-face each day at the regular scheduled class time, five days a week for 75 minute lessons during the duration of the Fall 2009 Semester. Both courses, the traditional offline and the hybrid, covered the same prescribed learning outcomes for this unit of study, sharing identical course topics and course content. The assignment guidelines, marking criteria, and due dates for the assignments were also identical. Both sections had the same instructor, and were conducted during the same semester. For the purposes of this research, only one unit was the focus for this study, and was used for comparison between the two classes.

The primary differences between the classes involved the mode of delivery of instruction – either traditional offline, or hybrid-based instruction. The traditional offline course was taught entirely face-to-face. All instructions in the regular classroom were given verbally and/or were written on overhead transparencies. Students enrolled in the hybrid section received their instruction online. Furthermore, all information pertinent to the lesson, including course notes and questions, was located on the course website in the hybrid version of the course. Personal Macbook computers were available for each student in the hybrid group in order to accomplish the lesson objectives every day. Labs and group work remained consistent between both the hybrid and the traditional offline class. All labs were done in real time face-to-face mode utilizing identical lab procedures. Additionally, discussions and group work for every content area within the syllabus occurred as part of normal procedures, utilizing identical face-to-face methods for both groups. The overall grading and content of the assignments remained consistent between both courses. I (primary researcher of this study, and the Chemistry 12 teacher) was present for the duration of both classes to provide instruction, support, and answer any questions that students presented.

In order to determine if there were any differences in student achievement levels and satisfaction between a traditional offline and a hybrid Chemistry 12 course unit, demographic surveys were used to gather information about students' prior experiences with varying course delivery formats. In addition, student marks for identical course assessments were compared between the two different classes, in order to determine student achievement variations. Finally, student satisfaction surveys were used to assess students' satisfaction with respect to course delivery methods. The two course delivery styles were then compared in order to address the research questions posed in this study.

3.3 Research Design and Internal Validity

This study was designed according to the tenants of quasi-experimental research. A quasi-experimental design is one that resembles an experimental design, however it lacks a main component: random assignment. Based on the comparative nature of the research questions, and the assignment of the subjects to either one of the two groups being studied, the specific type of quasi-experiment that was undertaken was a Non-Equivalent Group Design (NEGD). In the NEGD, we most often use a pre-test/post-test design involving intact groups that we think are similar as the treatment and control groups (Trochim, 2006). For instance, we may choose two comparable classes; however, we can never be certain that the groups selected are comparable. “Or, put another way, it's unlikely that the two groups would be as similar as they would if we assigned them through a random lottery” (Trochim, 2006, para. 1). The word "nonequivalent" in terms of this design generally means that assignment to either group was not random. “In other words, the researcher did not control the assignment to groups through the mechanism of random assignment” (Trochim, 2006, para. 2). As a result, the groups may have been different before the study was conducted.

While an attempt was made to ensure that the two groups were as comparable as possible, it was not feasible for the researcher to control the assignment to the groups on a random basis. This made the NEGD intrinsically prone to internal validity threats that needed to be addressed. The main such threat was the threat of selection on internal validity creating a selection bias in the study. This bias is the risk that any factor other than the ones being analyzed may have lead to the result observed. The key to addressing these validity issues was to make sure that the groups were as equivalent as they could be given the nature of the environment, and to see that the methodology was applied in a consistent manner.

The validity issues noted above were addressed by randomly selecting the test group (hybrid-format class) so that there was no bias as to the prior history or accomplishments of the students. In addition, a pre-assessment was administered to both groups in order to gain information about the distribution of students with respect to their achievement levels prior to the unit of instruction in either the traditional or the hybrid course delivery format. In addition to ensuring that both groups were comparable to begin with, students were selected for this study based solely on the fact that they were registered in one of the two offered course sections. Based on this design, the key internal validity issue was the degree to which the two groups were comparable before the study. If they were comparable, and the only difference between them was the treatment (i.e., hybridization of the course), post-assessment differences could then be attributed to this treatment. But that only applies if the groups were comparable to begin with, which was the case in this study. Furthermore, as all of the differences between the groups were observable (i.e., personal traits such as gender), selection bias was not of concern as a regression analysis was undertaken to account for these differences. Finally, although an attempt was made to try to ensure that the two groups were comparable at the onset of this study other factors may have affected its validity. For instance, it was not apparent why the student was registered for the course, or if there was any reason (unknown to the researcher) that had influenced his/her decision to participate in this study. In this case the selection was non-random and the differences between participants and non-participants may have been incorrectly ascribed to the treatment.

3.4 Context

As an increasing number of students are electing to enter the digital classroom, questions as to how to incorporate aspects of online education, combined with sound traditional offline teaching methods, have been of interest to many educators recently. As an example, beginning in the Fall Semester of 2009, the school where this research was undertaken began piloting the delivery of online classes from within the traditional offline classroom setting – a form of hybrid or blended learning. The goal was to provide courses via the online delivery method, while maintaining the presence of a classroom teacher able to provide guidance and technical support when necessary. In the hybrid format, students have the flexibility to work at their own pace during the allotted class time, with the guidance of a face-to-face teacher, and the structure of a physical classroom. In essence, the hybrid format promises to offer the “best of both worlds”.

In this hybrid setting, students were required to read all of the class notes online, follow all the links and examples online, and complete all the sample questions online. Additionally, students in both the hybrid class and the traditional offline class were given identical paper-based homework assignments to be completed outside of class time, as well as paper-based quizzes based on the homework, at the beginning of each class. Both classes also engaged face-to-face in similar group activities based on pre-determined topics, as well as carried out labs utilizing the same non-virtual face-to-face format during class time. Regardless of the form of instruction, either traditional offline or hybrid, all students attended school in the same physical space during regular school hours.

3.5 Population Selection

Participants in this study included students from two Chemistry 12 classes at a secondary school that is comprised of a total of 1,421 students with 751 males, and 670 females. The student population is largely multicultural, with students from many different ethnic backgrounds. Post-graduation data indicates that more than half the students in the school continue on into post-secondary education, and many students pursue science courses in their elective years in order to gain entrance into various post-secondary institutions.

All students from each class were surveyed about their prior experiences with web-based instruction, as well as whether they had previously completed the Chemistry 12 curriculum. At the outset of the course, a total of 64 students had registered for one of the two different Chemistry 12 classes. The criteria for inclusion in this study was: enrollment in either one of the two different sections of Chemistry 12 offered at the school, parental consent and student assent to participation for the duration of this research, and successful completion of Chemistry 11. Students who were taking Chemistry 12 for the second time were excluded from the data set. Students were placed in either the hybrid or traditional offline section, through random assignment by the school counselors and/or school administrators. Students were made aware of their specific section – either hybrid or traditional offline, on the first day of class. Where choices of course delivery formats were available (as in this study), students had the option of transferring sections if they decided to do so. Any changes to course section assignment were made through the school counselors and/or administrators within one-week of course commencement.

3.6 Research Sequence

Data collection for this study was divided into six different stages (refer to Table 4), and involved two separate Chemistry 12 classes (Class A: traditional offline cohort, and Class B: hybrid cohort). Students in both of the Chemistry 12 classes were expected to attend each day at the designated class time, as this is a normal procedure for this course. As mentioned previously, the main difference between the two classes was the mode of instruction – either traditional offline, or hybrid. The data collection was carried out over a 3-week period.

Stages 1 and 2 were used primarily for baseline data gathering. Stage 1 consisted of introducing the course to the two different classes (refer to Appendix A: Chemistry 12 Course Outline). A demographic survey to assess students' prior experience with different forms of instruction was administered to both classes (refer to Appendix B). The hybrid class (Class B), was also given a tutorial on accessing and navigating the course website that they would utilize for the duration of this unit of study.

In Stage 2, both classes were given an introduction to Chemistry 12, which served as an introductory activity (refer to Appendix C). The activity involved a review of the concepts covered in the Chemistry 11 curriculum that are necessary in order to ensure success in Chemistry 12. It is important to note that this activity was not used for data collection. Upon completion of the introductory activity, students in Class A and Class B, wrote a pre-assessment (refer to Appendix D), that provided the researcher with information about the distribution of students in terms of ability.

Stages 3 and 4 involved delivery of course content and materials. Variations with respect to course delivery format occurred during these two stages according to whether the class was delivered through hybrid or conventional formats. Of note here is that the online portion of the hybrid class was self-paced, whereas the same lesson for the traditional offline class was not self-paced, as the instructor was the presenter. The table below summarizes each lesson and the respective variations with respect to class delivery format.

Table 4

A Comparison of Course Delivery Formats

Lesson #	Class A – Traditional Offline Instructional Format	Class B – Hybrid Instructional Format
1	F2F Introduction	F2F Introduction
	F2F Introductory Group Activity	F2F Introductory Group Activity
	F2F Review of Course Outline	F2F Review of Course Outline + online link to course outline provided
	Hardcopy handouts	Hardcopy handouts
	Online Activity: Chemistry 12 Information Sheet	Paper-based Activity: Chemistry 12 Information Sheet
	Online Activity: “Why are you taking Chemistry 12?”	Paper-based Activity: “Why are you taking Chemistry 12?”
2	F2F Seating Plan	F2F Seating Plan
	Paper-based Activity: “Are you ready for Chemistry 12?”	Paper-based Activity: “Are you ready for Chemistry 12?”
	F2F Group Activity: Safety in the Science Classroom	F2F Group Activity: Safety in the Science Classroom
	Hardcopy handouts	Hardcopy handouts
	Homework: Paper-based Introduction	Homework: Online/email Introduction

Lesson #	Class A – Traditional Offline Instructional Format	Class B – Hybrid Instructional Format
	Homework: Paper-based	Homework: Paper-based
3	F2F Lesson – Safety	F2F Lesson - Safety
	Hardcopy handouts	Hardcopy handouts
	Paper-based Assignment in-class	Online Assignment in-class
	Homework Assignment: Paper-based	Homework Assignment: Paper-based
4	F2F Instructor/Group Lesson	F2F Instructor/Group Lesson
	In-class F2F Safety Review	In-class Online Safety Review
	Paper-based Safety Test in-class	Online Safety Test in-class
	Paper-based homework	Paper-based homework
5	Reaction Kinetics Day 1	Reaction Kinetics Day 1
	F2F traditional offline lesson and notes / examples and sample questions discussed F2F	Online lesson and notes / links to examples and sample questions
	Paper-based homework	Paper-based homework
6	Reaction Kinetics Day 2	Reaction Kinetics Day 2
	F2F Group discussion based on previous days lesson	F2F Group discussion based on previous days lesson
	F2F Questions based on previous lesson	F2F Questions based on previous lesson

Lesson #	Class A – Traditional Offline Instructional Format	Class B – Hybrid Instructional Format
	Paper-based quiz	Paper-based quiz
	F2F Alka Seltzer/Reaction Rates Demonstration	Online Alka Seltzer/Reactions Rates Demonstration
	F2F traditional offline lesson and notes / examples and sample questions discussed F2F	Online lesson and notes / links to examples and sample questions
	In-class F2F Group Activity	In-class F2F Group Activity
	Paper-based handouts	Paper-based handouts
	Paper-based homework	Paper-based homework
7	Reaction Kinetics Day 3	Reaction Kinetics Day 3
	F2F Group discussion based on previous days lesson	F2F Group discussion based on previous days lesson
	F2F Questions based on previous lesson	F2F Questions based on previous lesson
	Paper-based quiz	Paper-based quiz
	F2F traditional offline lesson and notes / examples and sample questions discussed F2F	Online lesson and notes / links to examples and sample questions
	Paper-based handouts	Paper-based handouts
	Paper-based homework	Paper-based homework
8	Reaction Kinetics Day 4	Reaction Kinetics Day 4
	F2F Group discussion based on previous days lesson	F2F Group discussion based on previous days lesson
	F2F Questions based on previous lesson	F2F Questions based on previous lesson

Lesson #	Class A – Traditional Offline Instructional Format	Class B – Hybrid Instructional Format
	Paper-based quiz	Paper-based quiz
	F2F traditional offline lesson and notes / examples and sample questions discussed F2F	Online lesson and notes / links to examples and sample questions
	Paper-based handouts	Paper-based handouts
	Paper-based homework	Paper-based homework
9	Reaction Kinetics Day 5	Reaction Kinetics Day 5
	F2F Group discussion based on previous days lesson	F2F Group discussion based on previous days lesson
	F2F Questions based on previous lesson	F2F Questions based on previous lesson
	Paper-based quiz	Paper-based quiz
	In-class paper-based review sheets	In-class online review sheets
	Homework: Complete paper-based review sheets	Homework: Complete online review sheets
10	Reaction Kinetics Day 6	Reaction Kinetics Day 6
	F2F Group discussion based on previous days lesson	F2F Group discussion based on previous days lesson
	F2F Questions based on previous lesson	F2F Questions based on previous lesson
	F2F Discussion of answers to homework	F2F Discussion of answers to homework
	Paper-based quiz	Paper-based quiz

Lesson #	Class A – Traditional Offline Instructional Format	Class B – Hybrid Instructional Format
	F2F traditional offline lesson and notes / examples and sample questions discussed F2F	Online lesson and notes / links to examples and sample questions
	Paper-based homework	Paper-based homework
11	Reaction Kinetics Day 7	Reaction Kinetics Day 7
	F2F Group discussion based on previous days lesson	F2F Group discussion based on previous days lesson
	F2F Questions based on previous lesson	F2F Discussion of answers to homework
	Paper-based quiz	Paper-based quiz
	In-class Paper-based Review Worksheet	In-class Paper-based Review Worksheet
12	Reaction Kinetics Day 8	Reaction Kinetics Day 8
	F2F Discussion of Answers of Review Worksheet	F2F Discussion of Answers of Review Worksheet
	F2F Real-time Group Lab Activity	F2F Real-time Group Lab Activity
13	Reaction Kinetics Day 9	Reaction Kinetics Day 9
	Hardcopy In-class Reaction Kinetics Unit Assessment	Hardcopy In-class Reaction Kinetics Unit Assessment

The main difference here was the manner in which lesson notes, examples, and discussion questions were delivered to the two groups. The hybrid group utilized the unit website, and the traditional offline group received identical information in the form of overhead notes, and/or verbally from the teacher.

Hybridization involves “blending” traditional offline and online components to varying degrees. In this study, the researcher selected to keep all forms of assessment, including both surveys, in a paper-based format, thereby maintaining forms of familiarity and comfort in the hybrid classroom. Also during Stage 3, a unit assessment (refer to Appendix E) was given to both Class A and Class B in order to compare whether course delivery format had an effect on student achievement levels. Stage 5 involved administering a student satisfaction survey to both classes. Questions in the survey included those related to student satisfaction with the course delivery method (refer to Appendix F).

During Stage 6, the researcher compared data from participants in both cohorts with respect to performance on the pre-assessment, as well as the post-assessment. Additionally, during this stage, the researcher began analysis of the pre-course demographic survey, and the post-course satisfaction surveys that were given to both cohorts. This stage in the research began after the course was completed, and final marks were submitted for both classes.

Table 5***Research Stages and Procedures for Class A and Class B***

Research Stages	Class A – Traditional offline Format	Class B – Hybrid Format
Stage 1	Course Introduction Course Outline Demographic Survey	Course Introduction Course Outline Demographic Survey Hybrid course tutorial
Stage 2	Introductory Activity Pre-Assessment	Introductory Activity Pre-Assessment
Stage 3	Traditional Offline Instruction of Reaction Kinetics Unit	Hybrid Instruction of Reaction Kinetics Unit
Stage 4	Post-Assessment	Post-Assessment
Stage 5	Student Satisfaction Survey	Student Satisfaction Survey
Stage 6	Data Analysis	Data Analysis

3.7 Data Sources

The following is a description of the instruments used in this study:

3.7.1 Demographic Survey

A demographic survey to assess students' prior experience with web-based instruction, along with participant demographics was administered to all students. Demographic information was collected to obtain descriptive characteristics of the study participants. Sample questions from

the demographic survey are listed in brief below, and may be viewed in their entirety in Appendix B: Demographic Survey.

A/ My gender is:

B/ My age is:

C/ My previous experiences with web-based courses include:

D/ I have / have not taken Chemistry 12 previously:

Any students who indicated in the demographic survey that they had previously taken Chemistry 12 were excluded from the data set, as one of the requirements to participate in this study was “no previous experience in Chemistry 12”.

3.7.2. Pre-Assessment: “Are you ready for Chemistry 12?”

The pre-assessment was used in order to determine the distribution of students’ marks with respect to the research group that they were in, and whether the two groups – Class A and Class B, were equivalent with respect to student achievement levels prior to the unit of study. The pre-assessment was based on questions from the Introductory Activity. Further, pre-assessment scores were used to serve as a comparison with the post-assessment scores providing information about whether the “treatment” (i.e., hybridization of course delivery), had an effect on student marks in comparison to the traditional offline class. Refer to Appendix D: “Are you Ready for Chemistry 12?” for a complete version of the Chemistry 12 pre-assessment. As a brief overview of the types of questions that were included in this assessment, three sample questions follow.

- i) What is the concentration of a solution that is made up of 2.93×10^{26} formula units of NaOH, dissolved in 2.50 L of water?
- a) 0.005 M
 - b) 195 M
 - c) 0.195 M
 - d) 12.20 M
- ii) How many grams of MgCl_2 are required in order to prepare 250.0 mL of a 1.00 M solution?
- a) 3.81×10^{-1} g
 - b) 3.81×10^2 g
 - c) 2.38×10^4 g
 - d) 23.8 g
- iii) What is the average atomic mass given the following relative abundance of each isotope for the element:
- | | |
|----------------------------|----------------------------|
| ^{40}Ca - 96.97% | a) 2.0×10^1 g/mol |
| ^{42}Ca - 0.64% | b) 400 g/mol |
| ^{43}Ca - 0.145% | c) 0.400 g/mol |
| ^{44}Ca - 2.06% | d) 4.0×10^1 g/mol |
| ^{46}Ca - 0.0033% | |
| ^{48}Ca - 0.18% | |

3.7.3. Post-Assessment –Reaction Kinetics Unit Assessment

The Reaction Kinetics Unit Assessment marked the completion of the unit of study for this research. This assessment was used to determine if there was a difference in achievement levels between the traditional offline class and the hybrid class. Both cohorts were administered the same assessment in a paper-based format, and marks from each class were compared to the pre-assessment in order to ensure that the results were a valid reflection of course-related achievement. For instance, the post-assessment included only those questions based on the unit of instruction. Marks from this assessment were also compared between both cohorts in order to determine which group had higher achievement scores. Refer to Appendix E: Reaction Kinetics Unit Assessment for a complete version of this instrument. Below are three sample questions extracted from this data instrument.

- i) If 55.0 mL of 0.200 M PbI_2 is mixed with 45.0 mL of 0.100 M PbI_2 , the concentration of the resulting PbI_2 solution is:
- a) 0.110 M
 - b) 0.050 M
 - c) 0.060 M
 - d) 0.160 M
- ii) Balance the following equations:
- a) $\text{___ H}_2 + \text{___ O}_2 \text{ ----> ___ H}_2\text{O}$
 - b) $\text{___ CrCl}_3 + \text{___ H}_2\text{S ----> ___ Cr}_2\text{S}_3 + \text{___ HCl}$
 - c) $\text{___ KClO}_3 \text{ ----> ___ KCl} + \text{___ O}_2$
 - d) $\text{___ CaO} + \text{___ C ----> ___ CaC}_2 + \text{___ CO}_2$

- e) $\text{___ NH}_3 + \text{___ H}_2\text{SO}_4 \text{ -----} > \text{___ (NH}_4\text{)}_2\text{SO}_4$
- f) $\text{___ Pb(NO}_3\text{)}_2 + \text{___ Cu -----} > \text{___ CuNO}_3 + \text{___ Pb}$
- iii) The empirical formula of a compound that contains 58.5% C, 7.3% H and 34.1% N is:
- a) $\text{C}_3\text{H}_2\text{N}$
- b) $\text{C}_2\text{H}_3\text{N}$
- c) $\text{C}_4\text{H}_6\text{N}_2$
- d) $\text{C}_2\text{H}_2\text{N}$

3.7.4. Student Satisfaction Survey

The student satisfaction survey was administered to both cohorts following the unit of instruction. The purpose of this survey was to assess students' satisfaction levels with the course delivery format. Refer to Appendix F: Student Satisfaction Survey. The researcher used a self-developed 20-question survey based on the literature reviewed (Refer to Chapter 2: Literature Review/ Satisfaction). A majority of the research reviewed that measured student satisfaction did it through a student survey that asked students' opinions about matters pertaining to their course experience. In general, repeatedly asked questions fell into four categories: perceptions of course content, access to course materials, communication levels with instructors and peers, and satisfaction with given grades. Based on this research trend, the researcher developed questions 1-20, and organized these questions into the four constructs mentioned above. Refer to Table 6 below for organization of survey questions and the corresponding constructs that have been utilized to measure student satisfaction with the course delivery format. The survey questions were multiple-choice and used the descriptors: "Strongly

Agree,” “Agree,” “Disagree,” “Strongly Disagree.” In order to reduce response bias and to encourage students to read and reflect on each statement, seven negatively worded items (items 1, 7, 9, 11, 13, 16, and 18) were included. These items were reverse scored for data analyses.

Table 6

Student Satisfaction Constructs and Corresponding Survey Items

SATISFACTION CONSTRUCT	SURVEY ITEM
PERCEPTIONS OF COURSE CONTENT	1. The course delivery format made it more difficult to understand the course content than in other science course I have taken.
	2. I believe that the course delivery format that was used in my class was a great way to study the Reaction Kinetics Unit.
	3. The course delivery format that was used in my class provided an environment that promoted my understanding of the Reaction Kinetics Unit.
	4. Overall, the course delivery format that was used in my class provided me with a successful learning experience.
	5. If provided with the opportunity, I would definitely take another science course delivered in the same format as this course was presented.
ACCESS TO COURSE MATERIALS	6. The course delivery format that was used in my class allowed me to easily access class notes.
	7. The course delivery format that was used in my class made it difficult to manage my class materials (such as notes and review questions).

SATISFACTION CONSTRUCT	SURVEY ITEM
ACCESS TO COURSE MATERIALS	<p>8. The course delivery format that was used in my class provided easy access to course materials, such as review packages.</p>
	<p>9. The course delivery format that was used in this class made it difficult to follow class notes at the pace that I found comfortable for me.</p>
	<p>10. Given the course delivery format that was used in this class, I found it easy to obtain all the classroom materials that I needed for each lesson.</p>
	<p>11. The course delivery format that was used in my class made it difficult for me to ask my teacher questions about the Reaction Kinetics Unit.</p>
COMMUNICATION LEVELS WITH INSTRUCTOR & PEERS	<p>12. The course delivery format that was used in my class prepared me to participate in classroom discussions.</p>
	<p>13. Given the course delivery format that was used in my class, it was difficult to ask my classmates questions about the Reaction Kinetics Unit.</p>
	<p>14. Given the course delivery format that was used in my class, my teacher promoted group interactions between classmates.</p>
	<p>15. Interacting with the teacher and with other classmates became more natural as the Reaction Kinetics Unit progressed.</p>

SATISFACTION CONSTRUCT	SURVEY ITEM
	16. The course delivery format that was used in my class, did not allow me to achieve the grades that I anticipated at the start of the course.
SATISFACTION WITH GIVEN GRADES	17. Given the course delivery format that was used in my class, the grades that I received are reflective of my effort in the Reaction Kinetics Unit.
	18. Given the course delivery format that was used in my class, I am not satisfied with the grades that I received on my assignments.
	19. Given the course delivery format that was used in my class, I was pleased with the grades that I received on my tests.
	20. Given the course delivery format that was used in my class, the overall grades that I received in the Reaction Kinetics Unit are better than what I expected at the start of the Unit.

A detailed description of all of the data sources and the corresponding research questions addressed is provided in Table 3.8 (B).

Table 7

Data Sources and Research Questions Addressed

Data Source	Purpose	Research Question Addressed
Demographic Survey	To collect participant demographic information and	N/A

Data Source	Purpose	Research Question Addressed
	information regarding inclusion in data set.	
Introductory Activity	To ensure both cohorts have identical background information prior to the unit of instruction.	N/A
Pre-Assessment	To determine the distribution of students' marks with respect to the research group that they are in, and whether the two groups – Class A and Class B, are equivalent with respect to student achievement levels. Also, pre-assessment scores were used to serve as a comparison with the post-assessment, providing information about whether the “treatment”, (i.e., hybridization of course delivery, has an effect on students' marks, and their course satisfaction).	How do grades differ on identical assignments and tests in traditional offline and hybrid formats?
Post-Assessment	To determine which method of instruction was more effective with respect to student achievement levels.	How do grades differ on identical assignments and tests presented in traditional offline and hybrid formats?
Student Satisfaction Survey	To assess students' satisfaction levels with the course delivery format.	What is the relationship between student satisfaction and course delivery method (traditional offline vs. hybrid)?

The collection of feedback from students is an important part of course delivery development and evaluation. Measuring course delivery program outcomes can be efficiently and effectively done through the use of survey research (Strachota, 2006). Of importance

however is that program evaluation must be conducted through the use of valid and reliable instruments. It is critical when conducting survey research that the instrument is more than a series of questions and that it measures what it is intended to measure. Therefore the typology in the student satisfaction survey instrument was developed by the researcher after a thorough review of the literature and informed by student satisfaction studies including those by Arbaugh (2000), Rochester & Pradel (2008), Moore & Kearsely (2005), Young & Duhaney (2008), So & Brush (2008), Behrman (2003), Buzzetto-More (2008), Dziuban, Moskal, & Brophy (2007), Johnson, Aragon, Shaik, & Palma-Rivas (2000), and Alonso & Norman (1996). In my review of the aforementioned studies, I found four constructs based on research by the authors that repeatedly appeared in the studies associated with student satisfaction with course delivery format. These constructs based on students enrolled in any course are: 1) Perceptions of course content, 2) Access to course materials, 3) Levels of instructor and peer interaction, and 4) Satisfaction with course grades. Refer to Table 8 for a list of the satisfaction constructs and the corresponding studies conducted that informed the creation of these constructs.

Table 8

Survey Instrument Constructs Associated With Student Satisfaction Studies

SURVEY INSTRUMENT CONSTRUCT	INFORMED BY:
PERCEPTIONS OF COURSE CONTENT	Arbaugh, (2000) Young & Duhaney, (2008) So & Brush, (2008) Behrman, (2003) Buzzetto-More, (2008)

SURVEY INSTRUMENT CONSTRUCT	INFORMED BY:
	Dziuban, Moskal, & Brophy, (2007) Johnson, Aragon, Shaik, & Palma-Rivas, (2000) Lin, (2008)
ACCESS TO COURSE MATERIALS	Arbaugh, (2000) Young & Duhaney, (2008) Behrman, (2003) Buzzetto-More, (2008) Johnson, Aragon, Shaik, & Palma-Rivas, (2000) Lin, (2008)
LEVELS OF INSTRUCTOR AND PEER COMMUNICATION	Arbaugh, (2000) Young & Duhaney, (2008) So & Brush, (2008) Dziuban, Moskal, & Brophy, (2007) Johnson, Aragon, Shaik, & Palma-Rivas, (2000) Lin, (2008)
SATISFACTION WITH COURSE GRADES	Arbaugh, (2000) Alonso & Norman, (1996)

The typology included in the student satisfaction survey is comprised of questions based on the above-mentioned constructs: perceptions of course content, access to course materials, levels of instructor and peer interactions, and satisfaction with course grades. These four constructs were foundational for the development of survey questions that served as a measure of student satisfaction. Satisfaction with courses has frequently been included as a dependent variable in studies of web-based education and Internet-based courses (Arbaugh,

2000). Given the recent use of this course delivery format, it is plausible to suggest that student satisfaction with hybrid-based courses is likely to determine whether a student elects to enroll in subsequent courses that are offered in this same format. If students are not satisfied with hybrid-based courses, they likely will stop taking them, which would have serious implications for their continued viability as an educational medium.

3.8 Data Analysis

In all, four sets of data were collected for this study in order to better understand the differences between students registered in the traditional offline course and those taking the hybrid course. First, a demographic survey was administered to students in both the traditional and the hybrid classes in order to assess students' prior experience with different forms of instruction, as well as to gather general student demographic data. Second, grades on an identical pre-assessment prior to the unit of instruction were compared between the same two classes in order to provide the researcher with information about the distribution of students in terms of ability and achievement. Third, a post-assessment was given in order to determine which method of instruction was more effective between the two classes with respect to achievement levels, by comparing the marks on this test in each class. Finally, a student satisfaction survey was administered in order to determine whether there was a difference between student satisfaction and course delivery format. The traditional offline class consisted of 23 registered students and the hybrid class consisted of 26 registered students. The completion rate for the demographic survey, pre-assessment, post-assessment, and student satisfaction survey was 100% for both the traditional and the hybrid classes. The data collected was analyzed and the results are discussed in Chapter 5.

Student achievement and student satisfaction were evaluated by comparing test scores between the two classes using identical assessments, and as an aggregate using overall test averages. The goal was to determine if there was a significant difference in student achievement and student satisfaction between the hybrid class and the traditional offline class. The use of the same notes, plus identical assignments and assessments allowed for a direct comparison between the two classes. All data analyses for the tests were conducted using SPSS Version 17.0 for Windows. The Independent Samples *t*-test was utilized to compare the mean scores of the two groups, the traditional class and the hybrid class, based on each of the following dependant variables: pre-assessment score, post-assessment score, perception of course content, access to course material, communication levels, and satisfaction with given grades. A *p* value of less than 0.05 ($p < 0.05$) was considered to indicate statistical significance. Descriptive statistics and frequencies were compiled to give means and percentages for demographic data. Aggregate totals for the student satisfaction survey allowed for the comparison of overall satisfaction scores between the two classes.

An assumption of the *t*-test is that the dependent variable is normally distributed and that the two groups have approximately equal variance on the dependent variable. In order to check for equal variance between the two groups, Levene's Test was computed in order to illustrate that the two groups are independent of one another. Levene's Test assesses the null hypothesis that the population variances are equal. If the resulting *p*-value of Levene's Test is less than some critical value ($p < 0.05$), the obtained differences in sample variances are unlikely to have occurred based on random sampling. The null hypothesis of equal variances may be rejected, and it can be assumed that there is a difference between the variance in the

population. Findings from these analyses produced the means and standard deviations for each set of information.

The student satisfaction survey administered to the traditional class was completed by 23 of the 23 students in the class, or 100% of the class. The identical survey administered in the hybrid class was completed by 26 of the 26 students, or 100% of the class. The satisfaction survey was comprised of 20 four-point Likert-type items, and the questions were organized based on the four satisfaction constructs (perceptions of course content, access to course materials, communication levels with instructors and peers, and satisfaction with given grades). Questions on the survey included: “The course delivery format promoted my understanding of the unit”, “The course delivery format allowed for easy access to class materials”, “The course delivery format allowed me to participate in classroom discussions”, “Given the course delivery format used in my class, I was *not* pleased with the grades that I received”. The scale focused on students’ satisfaction with the course delivery format and the likelihood of students taking future science courses in the hybrid format.

Of the 20 questions in the student satisfaction survey, 13 statements were positive while 7 included negative statements. The positive items were coded from 4 (strongly agree) to 1 (strongly disagree), and the negative items were coded from 1 (strongly agree) to 4 (strongly disagree) for each statement. Negative statements on the scale were recoded in order to bring all survey questions to a positive ordinal scale of agreement. In order to ensure the reliability of the scale utilized, the alpha reliability coefficient was computed for each of the four constructs on the satisfaction survey. The findings from these analyses served to provide the means and standard deviations for each set of information, and the results are discussed in Chapter 5.

In addition to the Independent Samples *t*-test, a factorial ANOVA was also carried out to statistically determine whether the gender and/or the age of a student had a significant effect on student achievement and student satisfaction based on course delivery format, as the researcher had collected basic demographic data from both classes. The results from the ANOVA were analyzed in order to determine whether a significant relation exists between:

- * Gender, achievement and course delivery format
- * Gender, satisfaction and course delivery format
- * Age (16 versus 17 year olds at the onset of the course), achievement and course delivery format
- * Age (16 versus 17 year olds at the onset of the course), satisfaction and course delivery format

The results from these analyses are presented and discussed with respect to statistical significance, in Chapter 5.

3.9 Construct Validity and Reliability of the Survey Instrument

Construct validity is the degree to which a test measures an intended hypothetical construct, or in other words, “the extent to which a measurement reflects the specific intended domain of content” (Carmines & Zeller, 1991, p. 20). Experts in the field of technology education, as well as statistics experts examined the survey constructs for validity with respect to the specific survey questions. The researcher’s survey was also reviewed and approved by the Statistical Consulting Office, (Faculty of Education, University of British Columbia, August 4, 2009). Several questions were modified or eliminated based on the

advice of these reviewers in order to ensure validity of the constructs that the survey instrument was comprised of. After content validity was addressed, the survey instrument was comprised of 20 items based on the four satisfaction constructs mentioned earlier.

To be effective, an instrument must have both construct validity and reliability (Strachota, 2003). Reliability describes how well a particular survey instrument provides consistent results, regardless of whom the method is used by or when it is used. Formally defined, reliability is “the consistency of your measurement, or the degree to which an instrument measures the same way each time it is used under the same condition with the same subjects. In short, it is the repeatability of your measurement”(Carmines & Zeller, 1991, p. 21). A measure is considered reliable if a person's score on the same test given twice is similar. Reliability is not measured; it is an estimate through internal consistency. Internal consistency estimates the reliability by grouping questions in a questionnaire that measure the same concept. For example, the student satisfaction survey had four sets of five questions that measured the same concept (student satisfaction). Once responses to the survey were collected, a correlation between those four groups of five questions was computed to determine if the student satisfaction survey instrument was reliable in measuring student satisfaction. Correlation values were calculated using Cronbach's Alpha, which divided all the questions in the survey instrument every possible way and computed correlation values for all of them, utilizing SPSS 17.0. Cronbach’s Alpha scores range from zero through one, with a coefficient closer to one indicating higher reliability. Reliability coefficients should be at least 0.70 or higher to be considered reliable for effective instruments (Wallen & Fraenkel, 2001). Reliability calculations were performed for all of the four constructs as can be seen in the table below.

Table 9***Reliability of Survey Constructs***

Satisfaction Construct	Number of Items	Alpha reliability Coefficient	Scale Reliable? Yes/No
Perceptions of course content	5	0.90	Yes
Access to course materials	5	0.70	Yes
Communication levels with instructors and peers	5	0.81	Yes
Satisfaction with given grades	5	0.79	Yes

The alpha reliability coefficient calculations indicate that the scales utilized are consistent, and that the survey instrument used to analyze data from both classes is a reliable tool for data collection.

3.10 Limitations of the Study

1. The students that were evaluated for this study were from two sections of a Chemistry 12 course offered at the secondary school where this study was conducted, in the fall of 2009. Factors such as whether the course was an elective or a prerequisite for a post-secondary institution, demographics, class time, class size, and student ability levels were limitations because this was not a random sampling of students and groups may have been different prior to the research being conducted.

2. Students registered in the hybrid course section were not aware that they were signing up for a hybrid class during the course selection process. In the fall of 2009, during the first week, after they had been informed of their respective sections, students had the option to transfer sections. Because of this, student opinions of the course delivery style at the completion of this study may have been biased. For instance, if a student was in the hybrid section and would have preferred to be in the traditional offline section, this may have affected his/her schedule with respect to other courses if he/she decided to switch sections. Although students may have had a preference and an option to switch from one course section to the other, it may not have been possible in terms of the other courses in which the student was already registered.
3. Time was a limitation of the study because all students who participated in this study were from the first semester of the school year. A sampling of courses and feedback from multiple semesters utilizing the hybrid course delivery format, and from multiple teachers would have served to strengthen the representation of survey results and their general validity.
4. The Chemistry 12 unit selected for this study may have also affected the overall results, as some students may have performed better in one unit over another in the hybrid format.
5. The Chemistry 12 course is comprised of five units. For this study, only one unit was compared between the hybrid and traditional offline course formats. If all five units had been compared between both of the cohorts, the overall results and validity would have been strengthened.

6. Limitations due to technology, such as bandwidth concerns may have also affected student achievement and satisfaction in the hybrid section. Some problems associated with bandwidth are Internet connectivity, busy Internet lines, and high Internet traffic problems (Akar et al., 2004). Unavoidable circumstances, such as students not being able to connect to the Internet to access the course website in and out of class may have affected the validity of this study.

7. As both cohorts received identical assignments and tests, a possibility of cross-cohort communication may have hindered the validity of the test scores. For example, if the first Chemistry 12 class discussed test questions with the second Chemistry 12 class receiving the same test, students in the second class may have already known what sorts of questions to expect on the test. Where possible, measures were taken to ensure a minimal time lag between the classes receiving the test. Another method taken to minimize such interference was the provision of multiple versions containing identical test questions.

4 ETHICAL CONSIDERATIONS

Approval for this research was obtained through the UBC Behavioural Research Ethics Board (refer to Appendix L: UBC Behavioral Research Ethics Board Approval) as well as from the Surrey School District (refer to Appendix M: Surrey School District Research Approval). Students were informed of the nature of the study (refer to Appendix G: Invitation to Participate). They were also informed that their participation was entirely voluntary, and student participation – or lack thereof – would not affect their grades. Students were assured that the names of students who provided consent or non-consent would not be revealed to the researcher until after the unit had been completed and the final grades for the course were submitted. They were also told that they could choose to withdraw from the study at any time, and that their withdrawal would not be revealed to the researcher, and would not in any way affect their grades or their relationship with the teacher or the school. Additionally, all participants were provided with sufficient time to decide whether or not they wished to participate in this study.

4.1 Protection of Privacy and Confidentiality

When teachers are involved in investigating their own practices, issues of potential coercion exist, and need to be addressed prior to the research being carried forward. In order to ensure that students were in no way under duress to participate in the study, this research approach incorporated the following measures:

1. Both the traditional offline course unit and the hybrid course unit shared identical course topics. Additionally, the same amount of information was covered in both classes, and both classes followed identical lesson plans, identical assignments, and the same lesson notes.

The assignment guidelines, marking criteria, and due dates for the assignments were also identical. The primary differences between the classes involved the mode of delivery of instruction – either traditional offline or hybrid-based instruction. Students were not asked to do anything different or unusual in the way that they learned, and all activities that have been described in the methodology chapter (refer to Chapter 3) are part of the normal practices and procedures for this course. Students were not required to spend any additional time within or outside of class time on this research.

2. In the Invitation to Participate Document (refer to Appendix G), the Parent Consent Form (refer to Appendix H), and the Student Assent Form (refer to Appendix I), students and their parents/guardians were assured that participation in this study was entirely voluntary. Students were assured that marks would not be influenced in any way by whether or not they decided to take part in this study. The consent and assent forms, and all the data collected over the course of the unit, were kept in a locked cabinet to which only the volunteer teacher had a key. Only code numbers or pseudonyms were used to identify all data that was stored. Students were not identified by name in any reports of the completed study, unless they specifically requested this.
3. During the Fall Semester in 2009 when this study was conducted, I was the only teacher instructing this course, and no other researchers were present in the classroom. Thus, students' obligation to participate would not be decreased.
4. A volunteer teacher met with my Chemistry students in both classes. The study was explained to students and they were invited to participate in the study. (Refer to Appendix G: Invitation to Participate). The research nature of the study was explained prior to the

Reaction Kinetics Unit of Study. Students were also informed that their participation was entirely voluntary and their consent or non-consent would not affect their grades in any way. Parents of the participants were also informed about the research through a Parent Consent Form (Refer to Appendix H: Parent/Guardian Consent Form). Students who provided consent to participate, with a parental signature, were included in the data set of the study. Students who received non-consent from their parents to participate in this study took part in the unit of instruction (as all activities were part of the normal classroom instruction), but were not included in the data set. In addition to seeking parental consent, students also provided signed Student Assent forms (refer to Appendix I: Student Assent Form), which provided students' individual consent to participate in this study. The volunteer teacher was asked by the researcher not to share the student identities or any of the data with the researcher until the course was completed and final marks had been assigned for the course at the end of the Fall Semester.

5. To ensure confidentiality, the students participating in the study were assigned a numerical identifier by the volunteer teacher. Students used their numerical identifiers on both surveys and both assessments. Both of the surveys and the assessments are a normal part of the course activities. It is important to note that the marks students received on the pre-assessment and the post-assessment, were incorporated into the students' final marks, as these are normal practices for this course. In order to maintain anonymity of students' marks on these two assessments, the volunteer teacher entered these marks and submitted them herself on the day that marks were due for submission to the school office. In this way, the marks from the two assessments that are normal practices for this course, were

- included in the students' final grades, while maintaining anonymity and confidentiality of study participants from the researcher.
6. Consent/Assent Forms: The researcher did not have access to these forms until final grades in Chemistry 12 for both sections had been assigned. Upon completion of Chemistry 12, the researcher was not responsible for grading the students any further and at this point was permitted access to the consent and assent forms.
 7. Data Sources (including surveys and unit assessments): Students participating in the study were assigned a numerical identifier to ensure confidentiality; their real names were not used in any written documents, unless they so requested. Students used their codes for all assessments and surveys. All data sources were kept in a locked filing cabinet accessible only to the volunteer teacher. Data was only accessed and analyzed after the course was over and students had been assigned their grades. Only the data of those participating in the study – those who had given parental consent and their own assent to participate – were included in the data set.
 8. The volunteer teacher was made aware of her responsibilities concerning privacy and confidentiality issues by the researcher in a briefing session before the start of the research study. The volunteer teacher did not have a relationship with students enrolled in the two courses, and maintained sufficient distance to guarantee confidentiality.
 9. Data collected for this study was accessible to the volunteer teacher throughout the entire study, and was made available to the researcher once final course grades had been assigned to the students in both of the Chemistry 12 classes. Parents and

students were also given access only to their own data if requested.

4.2 Researcher Bias

The researcher of this study was also the instructor, facilitator, and technology supporter for both the traditional offline and the hybrid classes. Carrying out this role made complete objectivity impossible since the researcher (myself) had a vested interest in the successful implementation of both the hybrid and the traditional offline units. The quantitative design methodology of this study, followed by complete student anonymity, did however allow for neutrality between both course sections.

5 RESULTS AND DATA ANALYSIS

5.1 Demographics

Of the 49 students involved in this study, 25 or 51.0% were male, and 24 or 49.0% were female. Overall, 17 students (35%) were 16 years of age, while 32 or 65% were 17 years old. See Table 10 below for a complete description of the classroom composition for the traditional offline class and the hybrid class.

Table 10

Descriptive Statistics for the Traditional Offline and Hybrid Classes

Instructional Format	Number of Students Age=16 yrs	Number of Students Age=17 yrs	Gender and Sample Size	
Traditional offline	11	12	Male	11
			Female	12
Hybrid	6	20	Male	14
			Female	12
Total	17	32	Male	25
			Female	24

The information collected in the demographic survey included: gender, age, previous experience with web-based courses, and prior experience with Chemistry 12.

5.2 Pre-Assessment and Post Assessment - Data and Analysis

The pre-assessment scores were used to compare the means of students in the traditional offline class versus students in the hybrid class. From the descriptive statistical analysis, the mean for the hybrid class ($n=26$) was found to be 61% ($SD = 22.03$) on the pre-assessment, and the mean for traditional offline class ($n=23$), was also 61% ($SD = 21.20$) on the pre-assessment. Results from the t -test indicate that there was no significant difference in pre-assessment scores between the traditional offline class and the hybrid class, $t(47) = 0.98$, ($p > 0.05$). In other words, students in the traditional offline class did not demonstrate scores significantly different from students in the hybrid class who wrote the pre-assessment. Results from the pre-assessment indicate that prior to the unit of instruction and the variation of course delivery format, both groups, the hybrid class and the traditional offline class, had similar grades (refer to Table 11).

The post-assessment was used to compare the means of students in the traditional offline class versus students in the hybrid class. From the descriptive statistics analysis, the mean score for the traditional offline class ($n=23$) was found to be 64% ($SD = 13.99$), whereas the mean for the hybrid class ($n=26$) was 63% ($SD = 21.18$). Results from the t -test indicate that there was no significant difference in post-assessment scores between the traditional offline class and the hybrid class, $t(43.67) = 0.84$, ($p > 0.05$). Results may be viewed in Table 12.

Table 11

Independent Samples T-Test Results for Pre-Assessment Scores

Instructional Format	Sample Size	Mean %	Std. Deviation	Levene's Test – Sig.	Degrees of Freedom	T-test – Sig. (2-tailed)	Results Significant? Yes/No
Traditional offline	23	61.66	21.20	0.70	47	0.98	No
Hybrid	26	61.80	22.03				

Note: Equal variances assumed

Table 12

Independent Samples T-Test Results for Post-Assessment Scores

Instructional Format	Sample Size	Mean %	Std. Deviation	Levene's Test – Sig.	Degrees of Freedom	T-test – Sig. (2-tailed)	Results Significant? Yes/No
Traditional offline	23	64.45	13.99	0.03	43.67	0.84	No
Hybrid	26	63.43	21.18				

Note: Equal variances not assumed

These results indicate that students in the traditional offline class did not score significantly better than students in the hybrid class who wrote the post-assessment. Therefore, when comparing pre-assessment scores to post-assessment scores between both classes, course delivery format did not affect student achievement levels, as both classes produced similar results.

5.3 Student Satisfaction Survey – Data and Analysis

In order to perform a comparative analysis based on the type of instruction — traditional offline or hybrid— and student satisfaction levels, composite scores were computed for each of the four survey constructs, rather than analyzing each survey question individually. Combined scores from both classes produced means that ranged from a low of 2.26 ($SD = 0.68$) for the survey satisfaction construct “Satisfaction with given grades” to a high of 2.99 ($SD = 0.44$) for the satisfaction survey construct “Access to course materials”. As a whole, responses to all survey questions within the four satisfaction constructs had means that were between “disagree” and “agree” on a scale that ranged from strongly agree (4), agree (3), disagree (2), and strongly disagree (1). Standard deviations ranged from the lowest at 0.36 for the survey construct “ Communication levels with instructors and peers” to the highest at 0.68 for survey construct "Satisfaction with given grades”. Refer to Table 13 below.

Table 13

Traditional Offline & Hybrid Course Delivery Student Satisfaction

Satisfaction Survey Construct	Mean Score		Standard Deviation	
	Traditional Offline Class	Hybrid Class	Traditional Offline Class	Hybrid Class
Perception of course content	2.87	2.49	0.44	0.66
Access to course materials	2.86	2.99	0.44	0.44
Communication with instructor and peers	2.93	2.55	0.36	0.57
Satisfaction with given grades	2.37	2.26	0.40	0.68

Upon initial examination, the traditional offline class produced higher means in three of the four satisfaction categories. Students in the traditional offline class had higher perceptions of course content, greater communication levels with the instructor and peers, and were more satisfied with their given grades than students in the hybrid class. A clearer view of student satisfaction based on course delivery format is gained by independently examining the similarities and differences of the two delivery styles and the satisfaction survey constructs. Additionally, *t*-test analysis is required in order to measure whether the differences noted between the two classes are of significance. Both are discussed below.

5.4 Student Satisfaction Survey Construct: Perception of Course Content

The “Perception of Course Content” construct was utilized to see how satisfied students in both classes were with respect to their perceptions of the course content, and if there was a difference between the two classes. The statements that comprised this construct can be viewed in Table 14.

Table 14

Perceptions of Course Content – Statements

	Scaled Statements on Survey Instrument
1	The course delivery format that was used in my class made it more difficult to understand the course content than in other science courses I have taken.
2	I believe that the course delivery format that was used in my class was a great way to study the Reaction Kinetics Unit.
3	The course delivery format that was used in my class provided for an environment that promoted my understanding of the Reaction Kinetics Unit.

Scaled Statements on Survey Instrument	
4	Overall, the course delivery format that was used in my class provided me with a successful learning experience.
5	If provided with the opportunity, I would definitely take another science course delivered in the same format as this course was presented.

Note: In the above table, numbers on the scaled statements correspond to the item number on the survey instrument.

From the descriptive statistical analysis, the mean score on a scale from 1 to 4 (1=strongly disagree, 2=disagree, 3= agree, 4=strongly agree) for the traditional offline class was found to be 2.88 ($SD = 0.44$), whereas the mean score for the hybrid class was 2.49 ($SD = 0.66$). These results indicate that students in the traditional offline class, on average, had a higher perception of the course content than students in the hybrid class. Results from the t -test indicate that there was a significant difference between the two classes, $t(43.68) = 0.02$, $p < 0.05$. Therefore, we can say that a significant difference was found with respect to perceptions of course content between the traditional offline class and hybrid class, where the students in the traditional offline class had a significantly more positive perception of the course content than students in the hybrid class. Refer to the table below for t -test results.

Table 15

Independent Samples T-Test Results for Perceptions of Course Content

Instructional Format	Sample Size	Mean Score	Std. Deviation	Levene's Test – Sig.	Degrees of Freedom	T-test – Sig. (2-tailed)	Results Significant? Yes/No
Traditional offline	23	2.88	0.44	0.003	43.68	0.02	Yes
Hybrid	26	2.49	0.66				

Note: Equal variances not assumed.

5.5 Student Satisfaction Survey Construct: Access to Course Materials

The “Access to Course Materials” construct was used to see if there was a difference in how satisfied students were in accessing course materials based on the course delivery format. The statements that comprised this construct can be viewed in the table below.

Table 16

Access to Course Materials – Statements

	Scaled Statements on Survey Instrument
6	The course delivery format that was used in my class allowed me to easily access class notes.
7	The course delivery format that was used in my class made it difficult to manage my class materials.
8	The course delivery format that was used in my class provided me easy access to course materials, such as review packages.

Scaled Statements on Survey Instrument	
9	The course delivery format that was used in this class made it difficult to follow class notes at the pace that I found comfortable for me.
10	Given the course delivery format that was used in this class, I found it easy to obtain all the classroom materials that I needed for each lesson.

Note: In the above table, numbers on the scaled statements correspond to the item number on the survey instrument.

From the descriptive statistical analysis, the mean for the traditional offline class was found to be 2.86 ($SD = 0.44$), whereas the mean for the hybrid class was 2.99 ($SD = 0.44$). Results from the Independent Samples t -test indicate that instructional format did not have a significant impact on access to course materials $t(47) = 0.30, p > 0.05$. Therefore, we can say that there was no significant difference in student satisfaction with respect to access of course materials between the traditional offline class and the hybrid class. Results of the t -test can be viewed in the table below.

Table 17

Sample T-Test Results for Access to Course Materials

Instructional Format	Sample Size	Mean Score	Std. Deviation	Levene's Test – Sig.	Degrees of Freedom	T-test – Sig. (2-tailed)	Results Significant? Yes/No
Traditional offline	23	2.86	0.44	0.78	47	0.30	No
Hybrid	26	2.99	0.44				

Note: Equal variances are assumed

5.6 Student Satisfaction Survey Construct: Communication Levels With Instructor and Peers

The “Communication Levels with Instructor and Peers” satisfaction construct was used to compare the means of students in the traditional offline class versus students in the hybrid class with respect to how satisfied students were with the levels of communication with the teacher and other classmates based on the course delivery format. The statements that comprised this construct can be viewed in the table below.

Table 18

Communication Levels with Instructor and Peers – Statements

	Scaled Statements on Survey Instrument
11	The course delivery format that was used in my class made it difficult for me to ask my teacher questions about the Reaction Kinetics Unit.
12	The course delivery format that was used in my class prepared me to participate in classroom discussions.
13	Given the course delivery format that was used in my class, it was difficult to ask my classmates questions about the Reaction Kinetics Unit.
14	Given the course delivery format that was used in my class, my teacher promoted group interactions between classmates.
15	Interacting with the teacher and with other classmates became more natural as the Reaction Kinetics Unit progressed.

Note: In the above table, numbers on the scaled statements correspond to the item # on the survey instrument.

From the descriptive statistics analysis, the mean for the traditional offline class was found to be 2.93 ($SD = 0.36$), whereas the mean for the hybrid class was 2.55 ($SD = 0.57$).

Results from the Independent Samples t -test suggest that the instructional format had a

significant effect on communication levels with the instructor and peers $t(42.93) = 0.01, p < 0.05$. Therefore, based on this analysis, we can say that there is a significant difference in student satisfaction with respect to communication levels between the traditional offline class and the hybrid class, where the traditional offline class was more satisfied than the hybrid class with communication levels with the instructor and peers. Refer to Table 19 for t -test results.

Table 19

Independent Samples T-Test Results for Communication Levels with Instructor and Peers

Instructional Format	Sample Size	Mean Score	Std. Deviation	Levene's Test – Sig.	Degrees of Freedom	T-test – Sig. (2-tailed)	Results Significant? Yes/No
Traditional offline	23	2.93	0.36	0.04	42.93	0.01	Yes
Hybrid	26	2.55	0.57				

Note: Equal variances are not assumed

5.7 Student Satisfaction Survey Construct: Satisfaction with Given Grades

The Satisfaction with Given Grades construct was used to compare the means of students in the traditional offline class versus students in the hybrid class with respect to how satisfied students were with the grades that they received upon completion of the course (Refer to Table 20).

Table 20

Satisfaction with Given Grades – Statements

	Scaled Statements on Survey Instrument
16	The course delivery format that was used in my class did not allow me to achieve the grades that I anticipated at the start of the course.
17	Given the course delivery format that was used in my class, the grades that I received are reflective of my effort in the Reaction Kinetics Unit.
18	Given the course delivery format that was used in my class, I am not satisfied with the grades that I received on my assignments.
19	Given the course delivery format that was used in my class, I was pleased with the grades that I received on my tests.
20	Given the course delivery format that was used in my class, the overall grades that I received in the Reaction Kinetics Unit are better than what I expected at the start of this unit.

Note: In the above table, numbers on the scaled statements correspond to the item # on the survey instrument.

From the descriptive statistical analysis, the mean for the traditional offline class was found to be 2.37 ($SD = 0.40$), whereas the mean for the hybrid class was found to be 2.26 ($SD = 0.68$). Results from the t -test indicate that there was no significant difference between the traditional offline class and the hybrid class, $t(0.71) = 0.48$, ($p > 0.05$). Based on these findings the instructional format did not have a significant effect on satisfaction with given grades. Refer to the table below for t -test results.

Table 21***Independent Samples T-Test Results for Satisfaction with Given Grades***

Instructional Format	Sample Size	Mean Score	Std. Deviation	Levene's Test – Sig.	Degrees of Freedom	T-test – Sig. (2-tailed)	Results Significant? Yes/No
Traditional offline	23	2.37	0.40	0.01	0.71	0.48	No
Hybrid	26	2.26	0.68				

Note: Equal variances are not assumed

Table 22***Summary of Results – Student Achievement and Satisfaction***

Variable Compared	Significant Difference in Means Between Traditional offline Class and Hybrid Class? (Yes/No)
Pre-Assessment	No (Traditional offline = Hybrid)
Post-Assessment	No (Traditional offline = Hybrid)
Student Satisfaction Construct: Perceptions of Course Content	Yes (Traditional offline > Hybrid)
Student Satisfaction Construct: Access to Course Materials	No (Traditional offline = Hybrid)
Student Satisfaction Construct: Communication Levels with Instructor and Peers	Yes (Traditional offline > Hybrid)

Variable Compared	Significant Difference in Means Between Traditional offline Class and Hybrid Class? (Yes/No)
Student Satisfaction Construct: Satisfaction with Given Grades	No (Traditional offline = Hybrid)

5.8 Questions Related to Student Demographics

As basic student demographic data had been collected at the onset of this study, questions emerged as to the effects of gender and age at the onset of the course. Therefore, in order to determine whether gender or age yielded differences in student achievement and student satisfaction based on the course delivery format, the following questions were addressed, and analyzed using the analysis of variance factorial design statistical test (ANOVA):

1. Are there differences in student achievement based on gender between the traditional offline class and the hybrid class?
2. Are there differences in student achievement based on the age of the student between the traditional offline and the hybrid class?
3. Are there differences in student satisfaction based on gender between the traditional offline class and the hybrid class?
4. Are there differences in student satisfaction based on the age of the student between the traditional offline class and the hybrid class?

The results from these tests are summarized in the table below:

Table 23

ANOVA Results of Student Achievement and Satisfaction by Selected Demographics between Traditional Offline and Hybrid Sections (n=49)

Variable Compared	Results of ANOVA for Gender Effects and Instructional Format	Results of ANOVA for Age Effects and Instructional Format
Achievement: Pre-Assessment	There was no significant main effect for treatment, $F(1, 45) = 0.11, p = 0.74$, and no significant interaction, $F(1, 45) = 2.21, p = 0.14$	There was no significant main effect for treatment, $F(1, 44) = 0.67, p = 0.42$, and no significant interaction, $F(1, 44) = 0.05, p = 0.83$
Achievement: Post-Assessment	There was a significant main effect for treatment, $F(1, 45) = 4.45, p = 0.04$, and no significant interaction, $F(1, 45) = 2.59, p = 0.12$	There was no significant main effect for treatment, $F(1, 44) = 0.13, p = 0.72$, and no significant interaction, $F(1, 44) = 1.02, p = 0.32$
Satisfaction Construct: Perception of Course Content	There was no significant main effect for treatment, $F(1, 45) = 0.38, p = 0.54$, and no significant interaction, $F(1, 45) = 0.51, p = 0.48$	There was no significant main effect for treatment, $F(1, 44) = 3.00, p = 0.09$, and no significant interaction, $F(1, 44) = 0.05, p = 0.83$
Satisfaction Construct: Access to Course Materials	There was no significant main effect for treatment, $F(1, 45) = 0.03, p = 0.85$, and no significant interaction, $F(1, 45) = 0.29, p = 0.59$	There was a significant main effect for treatment, $F(1, 44) = 10.14, p = 0.00$ and no significant interaction, $F(1, 44) = .00, p = 1.00$
Satisfaction Construct: Communication Levels with Instructor and Peers	There was no significant main effect for treatment, $F(1, 45) = 0.71, p = 0.41$, and no significant interaction, $F(1, 45) =$	There was no significant main effect for treatment, $F(1, 44) = 0.00, p = 0.95$, and no significant interaction, $F(1, 44) =$

Variable Compared	Results of ANOVA for Gender Effects and Instructional Format	Results of ANOVA for Age Effects and Instructional Format
	0.09, $p = 0.76$	1.91, $p = 0.17$
Satisfaction Construct: Satisfaction with Given Grades	There was no significant main effect for treatment, $F(1, 45) = 0.44, p = 0.51$, and no significant interaction, $F(1, 45) = 0.99, p = 0.33$	There was no significant main effect for treatment, $F(1, 44) = 0.34, p = 0.56$, and no significant interaction, $F(1, 44) = 0.01, p = 0.93$

Significant difference indicated by $p < 0.05$

Results from the ANOVA tests, indicate that there was no evidence of interaction between subject effects based on the gender and the age of students. In other words, there were no significant differences in achievement or satisfaction between males and females with respect to instructional format. Similarly, there were no significant differences found in achievement and satisfaction between 16 and 17 year olds with respect to course delivery.

5.9 Discussion of Results – Achievement and Satisfaction

After the data were analyzed for this study, research conducted in the two Chemistry 12 courses showed that both classes had similar grades on their pre- and post-assessments. However, despite a lack of significant differences with respect to student achievement levels, student satisfaction levels based on survey results were generally higher in the traditional offline course than in the hybrid course. To better understand these results, it is beneficial to examine each originally proposed research question individually in conjunction with the pre-assessment, post-assessment, and survey data. Also accompanying each research question are

my hypotheses to explain the research findings.

Research Question #1: What is the relationship between student satisfaction and course delivery method (traditional offline vs. hybrid) in high school chemistry?

A number of studies have shown that student satisfaction is greater in hybrid courses when compared to traditional offline courses (Young & Duhaney, 2008; So & Brush, 2008; Behrman, 2003; Buzzetto-More, 2008). Conversely, other studies have found that students are more satisfied in the traditional offline classroom when compared to the hybrid classroom (Johnson et al., 2000; Lin, 2008; Riffell & Sibley, 2005). Students' satisfaction is arguably one indicator of the effectiveness of a particular course delivery format. Based on a review of the literature noted above, four survey constructs targeted at assessing student satisfaction were developed. These constructs included: perceptions of course content, access to course materials, communication levels with instructors and peers, and satisfaction with given grades. Using these constructs, the student satisfaction survey was developed and analyzed using the Independent Samples *t*-test. Findings demonstrated that students in the traditional offline class were more satisfied than students in the hybrid class with respect to perceptions of course content ($t(43.68) = 0.02, p < 0.05$), as well as with communication levels with the instructor and peers ($t(42.93) = 0.01, p < 0.05$). Both of the above-mentioned satisfaction constructs yielded more positive responses and higher means for the traditional offline course as opposed to the hybrid course and these results were statistically significant. When looking at the remaining two satisfaction constructs (access to course materials and satisfaction with given grades), no significant differences were found in the means between the traditional offline and the hybrid class.

One possible explanation of the finding that students may actually be more satisfied with the traditional offline course over the hybrid course in terms of their perceptions of course content and their communication levels with the instructor and peers, may be due to the learning curve associated with the hybrid class. Students taking Chemistry 12 are under very specific time constraints, in addition to the general level of difficulty of the course itself. Students in the hybrid class may have found that rather than focusing exclusively on the course content, they had to learn the course format as well. Utilizing “new” means and learning the lessons in a manner that they were not accustomed to may have created a higher level of dissatisfaction with the hybrid course than the traditional offline course, even though tutorials to assist students with the hybrid format were offered at the onset of the course. For example, students in the hybrid class had to obtain their class notes online and follow web links in order to proceed through the various sections in the unit. Conversely, students in the traditional offline class received their class materials directly through the teacher in the form of overhead notes and verbal instructions or explanations. Students in the traditional offline class may also have higher perceptions of course content than their hybrid counterparts due to the ability to access a more engaging classroom environment facilitated by face-to-face lessons and instructions. In contrast, the hybrid students did not have similar opportunities, as a portion of each lesson was online. These results are consistent with those reported by Johnson Aragon, Shaik, and Palma-Rivas (2000) and Lin (2008), suggesting that the online environment may lack the social dimension that is imperative in face-to-face classroom experiences, thus leading to lower perceptions of course content. Additionally, hybrid students may lack the self-motivational and discipline skills needed during the online, self-paced portion of each lesson (Riffell & Sibley, 2005), leading to lower satisfaction levels

with respect to perceptions of the course. Students at the high school level require a certain level of personal responsibility and maturity in order to be successful with this course delivery format. Additionally, media literacy may have an impact as to how well students in the hybrid model are able to navigate through the online portion of a lesson, thereby impacting students' overall satisfaction with this format. Thus, in order to achieve a comparable level of satisfaction in the hybrid format, as in the traditional offline format, it may be necessary to provide additional institutional, technological, and pedagogical supports to ensure student satisfaction with respect to their perceptions of course content.

Results from this study also indicated that students in the hybrid class were not as satisfied with their communication levels with the instructor and peers as were the students in the traditional offline class. Two possible factors may explain these findings. First, students may have felt that they did not have a clear idea of the task in the hybrid format. For example, students in the hybrid class may have proceeded to the next section without fully understanding the reasoning behind specific questions posed in the hybrid format. In the traditional offline format, the instructor had more opportunities to check for student understanding prior to proceeding to subsequent materials. For instance, in a conventional classroom the instructor can ask students probing questions, or may be able to determine understanding from students' verbal comments, questions, and facial expressions. Certainly students in the hybrid class had similar opportunities to ask the instructor questions, however, these questions were on an individual basis (student to teacher) during the online portion of the lesson. Other students in the hybrid class did not have the benefit of hearing these questions or the response from the instructor. Furthermore, the instructor could not ask the 'same' questions in the hybrid class, as the online portion of each lesson was self-paced

within the classroom. Second, feedback and comments from the teacher may not have been sufficient in satisfying students' questions and needs in the hybrid course delivery format. For example, students in the hybrid section had the option of asking the instructor questions in class as well as through email correspondence. The responses to questions posed by individual students may not have been sufficient and checking for student satisfaction with the response was not always feasible. For students who took advantage of the instructor's availability in this informal setting (i.e., e-mail), this may have increased their satisfaction levels with respect to communication with the instructor and the quality of interaction (Riffell & Sibley, 2005). For students who did not use this mode of interaction in the hybrid class, satisfaction with communication may have been lower than in the traditional offline class due to a decreased perception of the quality of communication.

Students in the hybrid class communicated face-to-face, as well as through online means with the instructor and with other students, often with lag times and delays if the instruction was online or if students required instructor response through email. The traditional offline class by contrast, carried on all communication face-to-face and had many more opportunities to do so, possibly contributing to increased satisfaction levels in this regard. For example, over the course of the Reactions Kinetics Unit, students in the traditional offline course section had a total of nine face-to-face group activities. Conversely, the same numbers of activities were presented to the hybrid class, but these activities were posted online, and students did not have the same opportunity to discuss questions and concepts with their peers as these activities were self-paced. Additionally, even though both classes had regularly scheduled face-to-face time and group activities offline, the traditional offline class had more opportunities over the course of the lesson (overhead notes and

teacher-led lessons) to communicate with the instructor and with other students if they were unclear about a topic – a finding also mentioned by So and Brush (2008).

Over the course of each hybrid class, the instructor noticed the variation in time students took to complete tasks, with some students moving through the web links at a quicker pace than others (which did not necessarily indicate understanding of the task). As mentioned above, in the hybrid class, students were working on the lessons at their own pace. Therefore, students may not have had opportunities to discuss a particular section from a lesson with their peers, adding to their dissatisfaction with this course delivery format. This finding is contrary to that found by Lin (2008), who found greater student satisfaction levels in the hybrid class compared to the traditional class in the online component of the lessons due to the advantage of more flexible learning (i.e., through self-pacing) than a traditional course to meet diverse learning needs. For instance, in Lin's study (2008), the students in the hybrid class were satisfied that they could learn at their own pace instead of having to learn according to the instructors pace in the traditional offline class. The result – that students in the traditional offline class were more satisfied than students in the hybrid class with respect to perceptions of course content as well as communication levels with the instructor and peers – may depend on many different factors, as is evident in the mixed results noted in existing research.

The remaining two satisfaction constructs from the student satisfaction survey, “Access to Course materials”, and “Satisfaction with given grades”, yielded similar results in both classes. In other words, students in both classes were equally satisfied with the grades that they received and the ease with which they could access course materials. These findings were expected, given that one of the findings from this study indicated that there were no

differences in achievement levels between either of the two classes. Furthermore, both the hybrid and the traditional offline class had equal access to course materials in the form of paper-based, hardcopy handouts. Given the equivalent nature of these findings, it is not surprising that students in both classes were equally satisfied in this regard.

Research Question #2: How do Chemistry 12 course grades differ in traditional offline and hybrid course delivery formats?

This research question was addressed by comparing pre-assessment and post-assessment scores between the traditional offline class and the hybrid class. Findings showed that *students in the traditional offline class did not perform any better or any worse than students in the hybrid class with respect to achievement levels*. Both of the above-mentioned assessments produced similar means for the traditional offline course and the hybrid course.

In this study, student achievement was measured quantitatively by the pre- and post-assessment scores. A number of studies have shown that student achievement levels are greater in hybrid courses when compared to traditional offline courses (Riffell & Sibley, 2005; Gutierrez & Russo, 2005; Wellburn, 1996; Vilkoniene, 2009; Waite, 2007; Gutierrez, 2004). From an analysis of the data in the current study, it is evident that there was no significant relationship between the course delivery format and achievement levels of the Chemistry 12 students who participated in this study. That is, students in the hybrid class had similar achievement levels when compared to students in the traditional offline class. These findings are consistent with a study published by Baki & Guveli (2008). In their study, the researchers found that there was little difference between the test scores of 9th grade math students who used the hybrid format and those who used traditional offline means. These

results, along with the results from the current study, demonstrate that not all forms of hybrid learning result in improved student achievement levels when compared to their traditional offline counterparts. Ultimately, the success of a hybrid course is based on many factors, such as students' prior experiences with web-based courses, self-discipline, learning style/preference, and the course offered — to name just a few.

Understanding why students in the traditional offline section performed just as well as students in the hybrid section may involve a closer examination of the advantages and disadvantages associated with both of these course delivery formats. For instance, based on personal observations made in both the traditional offline and the hybrid classroom, it was evident that students were more comfortable in the traditional offline class since they were familiar with the format. There also may be more visual materials present in the traditional offline classroom to assist students in understanding the course material, which the instructor can draw upon when necessary in supplementing a lesson. For example, during the course of this study, the instructor frequently made reference to the Periodic Table hanging on the classroom wall, as well as to the different models suspended on the classroom ceiling. On the other hand, students in the hybrid class were not provided this same opportunity, as they were self-paced for the online portion of each lesson.

Other advantages with the traditional offline classroom include many more opportunities for the student and the instructor to meet face-to-face to aid in the understanding of the course content. In this study, face-to-face discussions in the traditional offline class were spontaneous and frequent. If a student had a question, the entire class would benefit from the response, as this was part of the traditional offline course format. In the hybrid class however, student queries were private, consisting of individual face-to-face

questions and email exchanges between the instructor and individuals. This presented few opportunities for the instructor to gauge class (and individual) comprehension while answering a particular question.

Finally, in the traditional offline class, the learning curve was lower for the instructor and for the students. Instructors in general likely have more experience with the traditional offline format, and are aware of how best to maximize student learning. In the hybrid format, more time and opportunity to instruct the course utilizing hybrid means may be required by instructors in order to be familiar with appropriate methods to maximize learning. For example, an instructor may need to be familiar with online scaffolding techniques such as WebQuests, to ensure that students successfully understand the concepts. In the traditional offline format, the instructor could use probing questions to elicit the same result. Therefore time and the number of previous opportunities instructors may have had to teach hybrid courses may contribute to student achievement.

The hybrid course format, unlike the traditional offline course format, requires a certain level of discipline on the part of the student. If during a hybrid lesson, a student decides to do the lesson on his/her own time at home, rather than in the class, following through with this commitment is necessary in order to be successful with the course. Comparatively, in the traditional offline format, the teacher has a specific lesson that is taught in the given class time; students do not have the option of completing this lesson at their own time, thus requiring less organization on the part of the student. Students in hybrid courses must take more responsibility for their learning, not only in completing the lessons unsupervised, but also in clarifying any confusion they may have, as they lack the benefit of their classmates' questions or real-time explanations.

6 CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

6.1 Conclusions

Although hybrid learning is being adopted at schools in the district, science teachers in the school where this research was conducted have espoused the implementation of these courses in a very guarded manner. Furthermore, there is a scarcity of research regarding the effectiveness of hybrid learning with respect to student achievement and satisfaction when compared to the traditional offline format at the secondary school level. This research then was conducted for several key reasons. First, if the hybrid course delivery format proved successful at the secondary school where this research was conducted, teachers would be more willing to adopt this format. Also information gained from this study would help match future hybrid classes and student needs within the school district where this study took place. This, in turn, is the first step to establishing a consistent delivery style for the hybrid format that will help ensure student success at the secondary level. Second, student feedback gained from this study will also help other teachers' better tailor lessons for future learners. Some traditional offline components were more successful than hybrid components (and vice versa) in this study. Recognizing and implementing these changes could result in increased student satisfaction and achievement. Also, student feedback gained from this study may be useful in keeping teachers informed about students' needs with respect to communication and perceptions of course content. By becoming aware of issues of importance to students, teachers can better address these issues in the classroom. Due to the "newness" of hybrid courses in BC secondary schools, results from this study will add to the overall state of knowledge on the topic. When combined with other studies and feedback from other high

schools, this study provides the local school board and other school districts a clearer picture of what is necessary to make hybrid courses successful and viable with respect to student achievement and student satisfaction. Additionally, the results from this study may also be of theoretical significance by providing researchers and scholars who are interested in web-based learning, data that may help to foster better understanding of the needs of high school students with respect to this course delivery format.

6.2 Limitations

It is important to note that this study was limited by several factors. First, the students who were evaluated for this study were from two sections of Chemistry 12 classes offered at the secondary school where this study was conducted. Students were selected for this study based solely on the fact that they were registered in one of the two course sections offered in the first semester of the school year. A sampling of courses and feedback from multiple semesters and multiple teachers would have strengthened the overall survey results and validity. Additionally, the Chemistry 12 unit selected for this study may have also affected the overall results, as some students may have performed better in one unit over another in the hybrid format. The Chemistry 12 course is comprised of five units, and the study followed only one. If all five units had been compared, the generalizability of the results would have been strengthened. Unavoidable circumstances, such as students not being able to connect to the Internet to access the course website were also of concern to this study, as all lesson notes for the hybrid class were available online.

Test results may have also been affected as a result of communication between the classes, as both cohorts received the same assignments and tests. Where possible, measures

were taken to ensure a minimal time lag between classes receiving a test and multiple versions containing identical questions were utilized.

6.3 Implications

6.3.1 Implications for Curriculum and Instruction

These results show that a hybrid course has the potential to be a useful alternative to the traditional offline class. The quantitative measures show that students performed equally well in both classes. The students in the hybrid class were slightly less satisfied with certain aspects of the course, but their feedback has provided valuable insight for improvement. It is vitally important to note the implications of the fact that the survey constructs “Perceptions of Course Content” and “Communication Levels with Instructor and Peers” yielded significantly lower satisfaction levels in the hybrid course compared to the traditional offline course delivery format. Suggestions for addressing these findings are offered in the Recommendations Section (Refer to Section 6.4).

6.3.2 Implications for Theory

The findings from this study confirm theoretical assumptions offered by other researchers, who suggest that the specific nature of the online component of hybrid learning is fundamentally important to how a program is perceived by students, how students perform, and how successful the program is over the long term. Benson and Samarawickrema (2009), for example, note that not all online environments are the same, and that important implications can emerge from aspects of separation – including the type of mobile technology being used and whether students are studying primarily on-campus, off-campus,

trans-nationally, or in specific contexts such as the home, the workplace, or, for certain types of employment, the field. The findings of this study may help to validate and broaden certain assumptions about the theory of transactional distance that Benson and Samarawickrema (2009) reference – formulated in part by Moore and Kearsley (2005). Transactional distance emphasizes the psychological (rather than geographical) distance between learners – a distance that can be closed, in part, by a carefully considered balance between dialogue, structure (course design), and learner independence. While the findings of this study may be read as a vindication of the instructor’s efforts to balance various elements appropriately according to Badrul Khan’s Octagonal Framework (Singh, 2003), it is worth considering the possibility that student dissatisfaction in some areas stems from an unrecognized imbalance originating (to cite one possibility) in an imperfect appreciation of the constraints imposed upon high school students in the home and school environment.

The study’s findings also have tentative implications for the *basis models of teaching and learning* – referenced in Fischer and Ostwald (2005) and Wackermann, Trendel, and Fischer (2010), and formulated by Oser and Baeriswyl (2001). The theory is a comprehensive set of models of learning processes, emphasizing learning through experience, concept building, and problem solving, among other skills. The theory encourages instructors and students to combine models while offering valuable guidelines about when to choose which model in order to promote effective teaching and learning. Wackermann, Trendel, and Fischer were able to show that teachers’ subjective beliefs, together with in-class actions, were key to academic outcomes – and that perceived instructional quality and student emotions were less influential than researchers initially believed. The findings of the present study with regard to both academic achievement and student perceptions of both the

traditional offline and hybrid program, are clearly relevant to the strength and integrity of the *basis models* theory in that not all hybrid courses may be developed according to any one specific model or theory— not least in the suggestion that it is difficult for an instructor to maintain complete objectivity, as well as the relative unimportance (at least in the short term) of student perceptions to outcomes.

However, strong validation of the study and its findings can be found in Badrul Khan's Octagonal Framework (2005), which, in important respects, echoes the *basis models*' emphasis on allowing hybrid-learning programs to pick and choose from relevant components' and combine those components in appropriate and productive ways. Khan's model is designed to assist educators in planning, developing, delivering, managing, and evaluating hybrid-learning programs on the basis of eight specific dimensions (institutional, pedagogical, technological, and ethical, as well as interface design, evaluation, management, and resource support). The ultimate goal of Khan's Octagonal Framework is full synchronization of content, format and learner, and it is this author's belief that the present study both confirms – and expands – Khan's emphasis on the importance of flexibility and adaptability within a clearly defined structure.

As with any novel learning initiative, instructors of hybrid-learning face many challenges. Opportunities for improvement always exist through reflecting on what worked and what did not in this new learning environment. To better understand the hybrid course delivery format, it is necessary to have a more complete view of the students involved, the instructional pedagogy, and the intended learning outcomes. Utilizing Badrul Khan's Octagonal Framework (2005) for this research, it is clear that in order to maximize student satisfaction in the hybrid-learning environment, a better balance of the dimensions from this

framework is required. As with any new course delivery format, the “correct” balance may be dependent upon a host of factors, and may include (but is not limited to) the course, the classroom environment, the students, and the instructor involved. Khan’s Framework (2005) is not static. In addition to the factors that need to be considered prior to the incorporation of the eight dimensions within this framework, variations with respect to the extent that these dimensions are incorporated need to be assessed following a preliminary assessment of the classroom environment. Data from this study indicate that although achievement levels of students in the hybrid class were comparable to the traditional offline class, satisfaction with the hybrid course delivery format was rated lower amongst students compared to the traditional offline format. A review of the dimensions that constitute the theoretical framework may assist in understanding these results better.

The constructs that yielded lower student satisfaction in the hybrid class compared to the traditional offline class included “Perceptions of course content” and “Communication levels with the instructor and peers”. Satisfaction may be improved in future hybrid Chemistry 12 classes by modifying the pedagogical, technological, and resource support dimensions of this framework. For instance, in terms of the pedagogical dimension, teaching and learning using the hybrid course delivery format needs to be modified to incorporate strategies and methods that would produce higher perceptions of the course content. As with the pedagogical dimension, the technological dimension may need to be altered to incorporate software that allows students to feel more comfortable with this type of learning environment. Finally, modifications to the resource support dimension, such as more frequent opportunities for communication with the instructor and peers, would improve student satisfaction.

Therefore, the main obstacles to incorporating Badrul Khan's Framework (2005) include finding the correct balance of dimensions, and the extent to which these factors are incorporated into the design and development of the hybrid course. Issues that may have contributed to lower satisfaction rates amongst students in the hybrid class may have been due to fewer face-to-face communication opportunities with classmates and the instructor, and the absence of an immediate response to email queries. In an effort to overcome these challenges, a key element to modifying the e-learning framework includes providing students opportunity for more frequent interactions, whether through asynchronous discussion with fellow students and the instructor, or by providing an online discussion board for students to communicate more regularly. The goal, simply, is to ensure that students are satisfied with their learning and that this process is meaningful and focused.

6.3.3 Implications for Research

Further research is required in order to have a clearer idea of the best combination of online and face-to-face components in hybrid course delivery formats, and their most appropriate use at the high school level. As this study was limited to a small population and only two classes during one semester, its scope is clearly limited. A survey using a larger population conducted over the course of several semesters might produce more reliable data about the effectiveness of the hybrid course model.

Additional studies utilizing more student feedback and both quantitative and qualitative measures are necessary. In this study, only quantitative data were gathered. For many of the satisfaction survey questions, responses were mixed. Incorporating individual student interviews or using repeated surveys over the course of the semester would yield

more detailed and consistent feedback, which would help identify what is working and what needs to be changed to create a more effective hybrid-learning environment.

Furthermore, once the high school where this study took place has implemented a clear and defined procedure for informing students as to course delivery format, further studies can be conducted to determine whether this knowledge represents a significant factor in achievement or satisfaction. If students are informed in advance that a class is in the hybrid-based format, and are still keen on registering for the session, they may have more positive perceptions of the course and be more successful.

6.4 Recommendations

The recommendations offered below represent an attempt to chart a future course of action in which satisfaction levels rise, serving to ensure the viability of a course delivery format that – at the very least – rivals the effectiveness of traditional offline methods. The recommendations derive directly from the information gained from the questions comprising each of the above-mentioned survey constructs – assessment of which revealed lower student satisfaction levels (refer to survey construct-specific recommendations in the next section). The real benefit of this study, however, is that it has shown that students seem resilient in either course delivery format with respect to their performance rates and achievement levels. Ultimately, understanding the course material is the students' responsibility, with the assistance, guidance, and direction of the teacher. Students seem to adapt to whatever course delivery format is provided to them for accomplishing that goal. From the results of this study and an analysis of the data, some new recommendations can be suggested that may be used by course designers and instructors to improve the success and viability of the hybrid

course delivery format.

6.4.1 Recommendations for Improving Perceptions of Course Content in the Hybrid Format

1. Web-based content that is more cognitively challenging and requires higher order thinking should be supplemented with additional face-to-face instruction and explanation. Activities and assignments in the hybrid course format need to be relevant to the course and their purpose and relevance needs to be clearly explained to students.
2. Mechanisms should be in place to ensure that students utilizing the hybrid course delivery format have a clear understanding of a concept prior to being allowed to proceed to the next section.
3. Allow students course delivery format options for specific course sections and/or course units. Students may find that they perform better and are more satisfied when using one format instead of another for some units. Although the feasibility of implementing this recommendation may be a challenge, the possibility of “open” sections and lateral movement between the traditional offline course section and the hybrid course section would prove beneficial.
4. Consider implementing successful traditional offline classroom practices into the hybrid model. This may involve better placement and reference to posters and models familiar in conventional classrooms within the online classroom format.
5. Improve students’ perceptions about their learning experience in the hybrid format through the use of more descriptive feedback and praise. Reassurance that students can be successful is fundamental to their perceptions of their own

abilities. This is especially true at the high school level.

6. Students need to understand what a hybrid course is and be aware that they are signing up for one prior to starting the course. The hybrid course delivery format is new for the school district in this study, and even though students may have a general idea of what it is, they may not fully comprehend the requirements. Understanding the format, with a discussion of the limitations, drawbacks, and benefits should be a requirement prior to enrollment.
7. A key to improving students' perceptions of course content includes providing the opportunity for regular interaction, be it "accessing self-assessment exercises online, Macromedia Flash animations, simulations and hyperlinked multimedia" (Teo & Williams, 2005, p. 4).
8. During the self-paced online portion of each lesson in the hybrid course, it is necessary to ensure that learning is meaningful in order for students to have a higher perception of this course delivery format. For instance, Collins and Ferguson (1993) suggest basic techniques for knowledge construction to assist students to recognize, judge, and organize patterns of information, and engage in constructive inquiry. These tools may be transferred to the online portion of the hybrid class in the form of interactive exercises, such as listing, table construction, and concept-mapping. The constructivist philosophy to improve student perceptions may also include case-based, problem-solving pedagogical teaching strategies in the form of discussion forums and summative course projects. As they engage in these types of learning activities, students construct their own knowledge, but also return this newly constructed knowledge back to

the system, adding to improved course perceptions (Teo & Williams, 2005).

6.4.2 Recommendations for Improving Communication Levels with the Instructor and Peers in the Hybrid Format

1. Instructors need to provide feedback and comments more quickly if students are submitting questions and assignments online, thereby decreasing the lag time/delay and increasing student satisfaction in this area.
2. It is important for instructors to provide weekly meetings with their students to keep them on course. This face-to-face time should be utilized to discuss concepts and material students have already covered, and to test them on it. If weekly meetings are not possible, every student should be required to participate in online discussion every week.
3. Instructors need to provide more opportunities for face-to-face discussion among the students themselves. Ideally, the face-to-face component of the hybrid course should provide an opportunity for the students to develop into more of a classroom community, which, admittedly, may not have happened completely in this format. Instructors should ensure that in-class components of a hybrid class provide an opportunity for student interaction, not just an opportunity to lecture using key materials or concepts.
4. Interaction with the instructor should focus not only on an overview of the course content, but also on sections of material that have been covered by the students on their own which may require clarification. This can be in the form of a “pre-view” and a “post-view” with the instructor.
5. The incorporation of unit assignments and final projects are designed to promote

collaboration between students, thereby improving communication levels in the hybrid class. Additionally, there should be an online work space for student groups to ask their peers questions, make announcements, engage in threaded discussion, and share information.

Provided that these recommendations are in place, students will be more likely to take courses utilizing this course delivery model.

6.5 Summary of Recommendations

The school district in which this study occurred, like many others, is going to continue to evolve and offer new course delivery formats. As it does, new challenges will arise. As the high school where this study took place enters its new “hybrid” phase, it faces the task of designing and implementing a hybrid course delivery style in a way that will successfully meet the needs of students by effectively combining the benefits of the face-to-face classroom with the flexibility of the online environment. As the school continues to offer more hybrid courses and collects additional feedback from students, its courses will improve, and the full potential of the hybrid course model may be more fully realized.

REFERENCES

- Akar, E., Ozturk, E., Tuncer, B. & Weithoff, M., (2004). Evaluation of a collaborative virtual learning environment. *Education and Training*, 46 (6/7), 343-352.
- Albrecht, B. (2006). Enriching student experience through blended learning. *Educause Center for Applied Research — Research Bulletin*, 12, 1-12.
- Arbaugh, J.B. (2000). Virtual classroom characteristics and student satisfaction with Internet-based MBA courses. *Journal of Management Education*, 24(1), 32-54.
- Arbaugh, J.B. (2004). Learning to learn online: A study of perceptual changes between multiple online course experiences. *Internet and Higher Education*, 7, 169-182.
- Arbaugh, J. B. (2005a). How much does “subject matter” matter? A study of disciplinary effects in on-line MBA courses. *Academy of Management Learning & Education*, 4(1), 57-73.
- Armstrong, S. (2007). Virtual learning 2.0. *Technology & Learning*, 28 (4), 26-29.
- Baki, A., and Guveli, E. (2008). Evaluation of a web based mathematics-teaching material on the subject of functions. *Computers & Education*, 51, 854–863. Retrieved June 24, 2009 from ScienceDirect.
- Barbour, M. K., & Reeves, T. (2009). The reality of virtual schools: A review of the literature. *Computers & Education*, 52 (2), 402-416.
- Barretto, S. F. A. Piazzalunga, R., & Colugnati, F. A. B. (2007) Measuring e-learning effectiveness in hybrid courses: A case report. Retrieved (June 9, 2009) from http://www.ipti.org.br:8080/site/pdf/meas_learning_eff.pdf
- Behrman, E. H. (2003). Reconciling content literacy with adolescent literacy: expanding literacy opportunities in a community-focused biology class. *Reading Research and Instruction*, 43 (1), 1-30.
- Beldarrain, Y. (2006). Distance education trends: Integrating new technologies to foster student interaction and collaboration. *Distance Education*, 27 (2), 139-153.
- Benson, R. and Samarawickrema, G. (2009). Addressing the context of e-learning using transactional distance theory to inform design. *Distance Education*, 30 (1), 5-22.
- Berube, D., Murray, C., & Schultz, K. (1999). Cadaver and computer use in the teaching of gross anatomy in physical therapy education. *Journal of Physical Therapy Education*, 13(2), 41-46.
- Boettcher, J. V. & Kumar, M. S. (2000, June). The Other Infrastructure: Distance Education’s Digital Plant. *Syllabus*, 13(10), 14-20.

- Bollinger, D.U., & Martindale, T. (2004). Key factors for determining student satisfaction in online courses. *International Journal on E-Learning*, 3(1), 61-67.
- Brown, J.S. & Adler, R. P. (2008). Mind on Fire, Open Education, the Long Trail, and Learning 2.0. *EDUCAUSE Review*, 43(1), 1-19.
- Bruner, J.S. (1996). *Toward a Theory of Instruction*. Cambridge, MA: The Belknap Press.
- Bruner, J.S., Wood, D., Ross, G. (1976). The Role of Tutoring in Problem Solving. *Journal of Child Psychology and Psychiatry*, 17 (2), 89-100.
- Bryant, S.M., Kahle, J.B., and Schafer, B.A. (2005). Distance education: A review of the contemporary literature. *Issues in Accounting Education*, 20 (3), 255-272.
- Bullen, M. (1999). What's the difference: A review of contemporary research on the effectiveness of distance learning in higher education. *Journal of Distance Education*, 14 (1), 102-114.
- Burns, N. & Grove, S. (1993). *The practice of nursing research conduct, critique, and utilization*. (2nd ed). Philadelphia: WB Saunders.
- Burrell-Ihlow, M. M. (2009). An investigation of teaching and learning: using course management software (CMS) in a typical face-to-face course. *International Journal on E-Learning*, 8 (1), 5-16.
- Buzzetto-More, N. A., & Sweat-Guy, R. (2006). Incorporating the hybrid learning model into minority education at a historically black university. *Journal of Information Technology Education*, 5, 153-164.
- Caladine, R. (1996). MOLTA: A Model of Learning and Teaching Activities. *Overview*, 3(1) 45-48.
- Carmines, E. G. & Zeller, R.A. (1991). *Reliability and validity assessment*. Newbury Park: Sage Publications. An introduction to research methodology that includes classical test theory, validity, and methods of assessing reliability.
- Chandra, V. & Lloyd, M. (2008). The methodological nettle: ICT and student achievement. *British Journal of Educational Technology*, 39 (6), 1087-1098.
- Chang, L, Chou, C., Chen, Z., & Chan, T. (2004). An approach to assisting teachers in building physical and network hybrid community-based learning environments: the Taiwanese experience. *International Journal of Educational Development*, 24 (4), 383-396.
- Chang, V., & Fisher, D. (2003). The validation and application of a new learning environment instrument for online learning in higher education. In M.S. Khine & D. Fisher (Eds.), *Technology-rich learning environments: A future perspective* (pp. 1-18). Singapore: World Scientific.

- Chew, E., Jones, N. & Turner, D. (2008). Critical Review of the Blended Learning Models Based on Maslow's and Vygotsky's Educational Theory. *In Hybrid Learning and Education*, 5169. Berlin: Springer Berlin/Heidelberg.
- Collins, M. (2000). Comparing web, correspondence and lecture versions of a second-year non-major biology course. *British Journal of Educational Technology*, 31 (1), 21-27.
- Chomsky, N. (1998). *Language and Problems of Knowledge*. Cambridge, MA: The MIT Press.
- Condie, R., & Livingston, K. (2007). Blending online learning with traditional offline approaches: changing practices. *British Journal of Educational Technology*, 38 (2), 337-348.
- Cook, A. (2008). A literature review of K-12 virtual learning communities. EdCmm 802. Retrieved May 10, 2009 from <http://www.usask.ca/education/coursework/802papers/cook/index.htm>.
- Cook, T. (2006). Collaborative Action Research within Developmental Evaluation: Learning to See or the Road to Myopia. *Evaluation* 12(4), 418-436.
- Cook, J. & Smith, M. (2004). Beyond formal learning: Informal community eLearning. *Computers & Education*, 43(1-2), 35-47.
- Daniels, S.E. & Walker, G.B. (1996). Collaborative learning: Improving public deliberation in ecosystem-based management. *Environmental Impact Assessment Review*, 16(2), 71-102.
- Delman, C. (2000). *A Parallel Postsecondary Universe: The Certification System in Information Technology*. Washington, DC: US Department of Education.
- Dewey, J. (1916). *Democracy and Education: An Introduction to the Philosophy of Education*, New York, NY: Cosimo.
- Dick, B. (2002). Action research: Action and research. Retrieved May 3, 2009 from <http://www.scu.edu.au/schools/gcm/ar/arap/aandr.html>
- Dick, B., & Swepson, P. (1997). Action Research FAQ (Frequently asked questions file). Retrieved May 3, 2009 from <http://www.scu.edu.au/schools/gem/ar/arp/arfaq.html>
- Dziuban, C., Moskal, P., & Hartman, J. (2005). Higher education, blended learning, and the generations: Knowledge is power—No more. In J. Bourne & J. C. Moore (Eds.). *Elements of quality online education: Engaging communities*. Needham, MA: Sloan Center for Online Education.
- El-Gayar, O., & Dennis, T. (2005). Effectiveness of hybrid learning environments. *Issues in Information Systems*, 1 (1), 176-182.

- Fillion, G., Limayem, M., Laferriere, T., & Mantha, R. (2009). Integrating ICT into higher education: Investigating onsite and online professors' points of view. *International Journal on E-Learning*, 8(1), 17-55.
- Fischer, G., & Ostwald, J. (2005). Knowledge Communication In Design Communities. In R. Bromme, F. W. Hesse & H. Spada (Eds.), *Barriers and Biases in Computer-Mediated Knowledge Communication* (pp. 213-242). New York, N.Y.: Springer.
- Fredericksen, E., Fredericksen, A., Pickett, P., Shea, K. (2000). Student satisfaction and perceived learning with online courses: principles and examples from the SUNY Learning Network, *Journal of Asynchronous Learning Networks* 14(2).
- Gaddis, B., Napierkowski, H., Guzman, N., & Muth, R. (2000). A comparison of collaborative learning and audience awareness in two computers-mediated writing environments. *Paper presented at the Association for Educational Communications and Technology, Denver, CO.*
- Gardner, H. (1993). *Frames of Mind: The Theory of Multiple Intelligences*. New York, NY: Basic Books.
- Garrison, D.R. & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education*, 7(2), 95-105.
- Gery, G. (2002). Performance Support – Driving Change. In Allison Rossett, (Ed.), *The ASTD E- Learning Environment* (pp. 24-37). New York, NY: McGraw-Hill Professional.
- Gibbs, G. (1992). *Assessing More Students*. Oxford: Oxford Brookes University.
- Glazer, E. (2001). Learning in communities. In M. Orey (Ed.), *Emerging perspectives on learning, teaching, and technology*. Retrieved May 1, 2009, from <http://projects.coe.uga.edu/epltt/>
- Graham, C. R. (2005). Blended learning systems: Definition, current trends, and future directions. In C. J. Bonk & C. R. Graham (Eds.). *Handbook of blended learning: Global perspectives, local designs* (pp. 3–21). San Francisco: Pfeiffer Publishing.
- Greeno, J.G. & Hall, R.P. (1997, Jan.). Practicing representation: Learning with and about representational Forms. *Phi Delta Kappan*, 78, 361-367.
- Gould, T. (2003). Hybrid classes: Maximizing institutional resources and student learning. Proceedings of the 2003 ASCUE Conference. June 8-12, 2003, Myrtle Beach, South Carolina.
- Gunnerson, S. (2004). Critical literature review: The importance of learner control in an online learning environment. BUS 5000 research methods. Retrieved June 3, 2009 from: <http://www.nthdegree.com.au/sverre/university/bus5000/assignment1.pdf>

- Gutierrez, D. (2004). A comparative study between a traditionally taught criminology course and a computer hybrid course: Does technology in the classroom make a difference? *Journal of College Teaching and Learning*, 1 (3), 59-64.
- Gutierrez, D., Wiese, J., Lopez, N., Portello, N. and Beninati, A. (2004). Student perceptions of computer hybrid courses across three disciplines: What students think about hybrid courses and what type of delivery format they prefer. *Journal of College Teaching and Learning*, 1 (8), 1-6.
- Heinz, A. & Proctor, C. (2004). Reflections on the Use of Blended Learning. *Education in a Changing Environment*. University of Salford, Education Development Unit.
- Hernandez, R., Pardo, A., & Kloos, C. D. (2007). Creating and deploying effective e-learning experiences using LRN. *IEEE Transactions on Education*, 50 (4), 345-351.
- Hodgins, W. (2002). Learnativity: Into the Future. In Allison Rossett, (Ed.), *The ASTD E-Learning Handbook* (pp.38-57). New York, NY: McGraw-Hill Professional.
- Hofstein, A. & Lunetta V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education*, 88, 28-54.
- Honeyman and Miller (1993). "Agriculture distance education: A valid alternative for higher education? *Proceedings of the National Agricultural Education Research Meeting* 67-73.
- Hong, K. & Hong, S. (2002). Relationships between students and instructional variables with satisfaction and learning from a web-based course. *Internet and Higher Education* 5(3), 267-281.
- Hu, W. (2009, Feb. 1). Schools won't require online course. Yet. *The New York Times*, NJ Section, pg. 1. Retrieved April 4, 2009, from LexisNexis Academic.
- "Hybrid learning." Retrieved Feb 9, 2009, from <http://media.njit.edu/hybrid/rationale.php>
- Jiang, M., Ting, E. (1999). A study of students' perceived learning in a web-based online environment. Paper presented at the World Conference on the World Wide Web and Internet Proceedings Honolulu, Hawaii, October 24-30.
- Johnson, S.D., Aragon, S.R., Shaik, N., Palma-Rivas, N. (2000). Comparative analysis of learner satisfaction and learning outcomes in online and face-to-face learning environments. *Journal of Interactive Learning Research*, 11 (1), 29-49.
- Jonsson, B. (2005). A case study of successful e-learning: A web-based distance course in medical physics held for school teachers of the upper secondary level. *Medical Engineering & Physics*, 27 (7), 571-581.
- Jukes, I., McCain, T., Kelly F. (2009) *Teaching the digital generation – no more cookie cutter high schools*. Los Angeles, CA: Corwin Press

- Karuppan, C.M. (2001). Web-based teaching materials: A user's profile. *Internet Research* 11(2), 138-148.
- Khan, B. (2005). *Managing E-Learning Strategies: Design Delivery, Implementation and Evaluation*. London, UK: Information Science Publishing.
- Khattab, M. (2006). *Literature Review*. Retrieved Feb 8, 2009 from: <https://www.msu.edu/~myra/research/review.htm>
- Lago, M. E. (November 2000). The Hybrid Experience: How Sweet It Is! *Converge Magazine*. Retrieved May 3, 2009 from <http://www.convergemag.com/Publications/CNVGNov00/hybrid/index.shtm>
- Leasure, A.R., Davis, L., & Thievon, S.L. (2000). Comparison of student outcomes and preferences in a traditional offline vs. World Wide Web-based baccalaureate nursing research course. *Journal of Nursing Education* 39(4), 149-154.
- Lee, C., Yeh, D., Kung, R., & Hsu, C. (2007). The influences of learning portfolios and attitudes on learning effects in blended e-learning for mathematics. *Journal of Educational Computing Research*, 37 (4), 331-350.
- Leh, A. S. (2002). Action Research on Hybrid Courses and their Online Communities. *Education Media International*, 39 (1), 31-38.
- Lent, R. W., Singley, D., Sheu, H., Schmidt, J. A., & Schmidt, L. C. (2007). Relation of social-cognitive factors to academic satisfaction in engineering students. *Journal of Career Assessment*, 15, 87-97.
- Leung, C. (2003). Providing navigation aids in online learning helps support user control: A conceptual model on computer-based learning. *The Journal of Computer Information Systems*, 43 (3), 10.
- Limniou, M., Papadopoulos, N., & Whitehead, C. (2009). Integration of simulation into pre-laboratory chemical course: Computer cluster versus WebCT. *Computers & Education*, 52, 45-52. Retrieved November 11, 2009, from ScienceDirect.
- Lin, Q. (2008). Student satisfactions in four mixed courses in elementary teacher education program. *The Internet and Higher Education*, 11, 53-59.
- Lowry, P. B., Nunamaker, J. F., Booker, Q. E., Curtis, A., Lowry, M., R. (2004). Creating hybrid distributed learning environments by implementing distributed collaborative writing in traditional offline educational settings. *IEEE Transactions on Professional Communication*, 47 (3), 171-189.
- Martin, W., (2009). Using learning environments as a metaphor for educational change. *On the Horizon*, 17 (3), 181-189.

- McCray, G. E. (2000). The hybrid course: Merging on-line instruction and the traditional offline classroom. *Information Technology and Management*, 1, 307-321.
- Mills, G. (2003). *Action research: A guide for the teacher researcher*. (2nd ed.). NJ: Merrill Prentice Hall.
- Mitchell, S. (2008). Easy Wiki Hosting, Scott Hanselman's blog, and Snagging Screens. *MSDN Magazine*. Retrieved August 20, 2010 from <http://msdn.microsoft.com/en-us/magazine/cc700339.aspx>.
- Mutum, Dilip and Wang, Qing (2010). "Consumer Generated Advertising in Blogs". In Neal M. Burns, Terry Daugherty, Matthew S. Eastin (Eds) *Handbook of Research on Digital Media and Advertising: User Generated Content Consumption (Vol 1)*, IGI Global, 248-261.
- MU researcher studies effectiveness of traditional offline and blended learning environments. (22 September, 2008). Retrieved April 18, 2009 from www.firstscience.com.
- Moore, M.G., & Kearsley, G. (2005). *Distance education: A systems view* (2nd ed.). Belmont, CA: Wadsworth.
- Murphy, K.L. & Cifuentes, L. (2001). Using web tools, collaborating, and learning online. *Distance Education*, 22(2), 285-305.
- Nichols, M. (2008). E-Learning in context. Retrieved May 11, 2009 from <http://akoao-tearoa.a.a.nz/sites/default/files/ng/group-661/n877-1--e-learning-in-context>.
- Northrup, P. (2002). A Framework for Designing Interactivity into Web-Based Instruction. In Allison Rossett, (Ed.), *The ASTD E-Learning Handbook*, 127-138. New York, NY: McGraw-Hill.
- Oblender, T.E. (2002). A Hybrid Course Model: One Solution to the High Online Drop out Rate. *Learning and Teaching with Technology*, 29(6), 42-46.
- Olapiriyakul, K., & Scher, J. M. (2006). A guide to establishing hybrid learning courses: Employing information technology to create a new learning experience, and a case study. *Internet and Higher Education*, 9, 287-301.
- Oliver, R. & Omari, A. (2001). Student responses to collaborating and learning in a web-based environment. *Journal of Computer-Assisted Learning* 17(1), 34-47.
- Oser, F., & Baeriswyl, F. (2001). Choreographies of teaching: Bridging instruction to learning. In V. Richardson (Ed.), *Handbook of research on teaching* (4th ed.). Washington, DC: American Educational Research Association.
- Paivio, A. (1969). Mental imagery in associative learning and memory. *Psychological Review*, 76(3), 241-263.

- Paivio, A. (1971). *Imagery and verbal processes*. New York, NY: Holt, Rinehart, and Winston.
- Paivio, A. (1986). *Mental representations: a dual coding approach*. Oxford, UK: Oxford University Press.
- Piaget, J. (1929). *The Child's Conception of the World*. London, UK: Routledge and Kegan Paul, Ltd.
- Piaget, J. (1930). *The Child's Conception of Physical Causality*. London, UK: K. Paul, Trench, Tubner & Co.
- Piaget, J. (1953). *The Origins of Intelligence in the Child*. London, UK: Routledge.
- Piccoli, G., Ahmad, R. and Ives, B. (2001). Web-Based Virtual Learning Environments: A Research Framework and a Preliminary Assessment of Effectiveness in Basic IT Skills Training. *MIS Quarterly*, 25(4), 401-426.
- Pinker, S. (1994). *The Language Instinct: The New Science of Language and Mind*. London, UK: Penguin.
- “Podcast Production” President and Fellows of Harvard College. Retrieved August 20, 2010 from <http://isites.harvard.edu/icb/icb.do?keyword=k1967&pageid=icb.page23750>
- Power, M. (2008). A dual-mode university instructional design model for academic development. *International Journal for Academic Development*, 13 (1), 5-16.
- Reigeluth, C.M. (1999). *Instructional Design Theories and Models: A New Paradigm of Instructional Theory*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- Richardson, J. (2009). Face-to-Face Versus Online Tutoring Support in Humanities Courses in Distance Education. *Arts & Humanities in Higher Education*, 8 (1), 69–85.
- Rieber, LP. (1996, June). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology Research and Development*, 44(2), 43-58.
- Reasons, S.G. (2004). Hybrid Courses – Hidden Dangers? *Distance Education Report*, 8(73), 3-7. Retrieved March 3, 2009 from WilsonWeb.
- Richardson, J. (2000). Teacher research leads to learning, action. *Tools for Schools*, February-March. Retrieved January 10, 2009, from www.nscd.org
- Riffell, S. K., & Sibley, D.F. (2004). Can hybrid course formats increase attendance in undergraduate environmental science courses? *Journal of Natural Resources and Life Sciences Education*, 33, 1–5.

- Riffell, S., & Sibley, D. (2005). Using web-based instruction to improve large undergraduate biology courses: An evaluation of a hybrid course format. *Computers & Education*, 44 (3), 217-235. Retrieved on April 22, 2009 from Science Direct.
- Rivera, J. C., & Rice, M. L. (2002). A Comparison of Student Outcomes & Satisfaction Between Traditional offline & Web Based Course Offerings. *Online Journal of Distance Learning Administration*, V (3). Retrieved May 1, 2009 from <http://www.westga.edu/~distance/ojdla/fall53/rivera53.html>
- Rochester, C.D., & Pradel, F. (2008). Students' Perceptions and Satisfaction With a Web-Based Human Nutrition Course. *American Journal of Pharmaceutical Education* 72(4) Article 91, 1-7.
- Rosenberg, M. J. (2001). *E-Learning: Strategies for Delivering Knowledge in the Digital Age*. New York, NY: McGraw-Hill.
- "satisfaction." In *The Oxford Pocket Dictionary of Current English*. 2009. Retrieved July 01, 2009 from Encyclopedia.com: <http://www.encyclopedia.com/doc/1O999-satisfaction.html>
- Shaw, G.P. & Pieter, W. (2000). The use of asynchronous learning networks in nutrition education: student attitude, experiences and performance, *Journal of Asynchronous Learning Networks* 4(1), 40-51.
- Shen, R., Wang, M., & Pan, X. (2008). Increasing interactivity in blended classrooms through a cutting-edge mobile learning system. *British Journal of Educational Technology*, 3 (6), 1073–1086.
- Sherry, L. (1996). Issues in distance learning. *International Journal of Educational Telecommunications*, 1 (4), 337-365.
- Silverman, R.M., Taylor, H.L., & Crawford, C. (2008). The role of citizen participation and action research principles in Main Street revitalization; an analysis of a local planning project. *Action Research* 6(1), 69-93.
- Singh, H. (2003, Dec.). Building Effective Blended Learning Programs. *Educational Technology*, 43(6), 51-54.
- Smith, P.L., & Dillon, C.L. (1999). Comparing distance learning and classroom learning: Conceptual considerations. *The American Journal of Distance Education*, 12(2), 6-23.
- So, H-J. & Brush, T. A. (2008). Student perceptions of collaborative learning, social presence and satisfaction in a blended learning environment: Relationships and critical factors. *Computers & Education*, 51, 318–336. Retrieved December 11, 2008, from ScienceDirect.

- Spiegel, H. (2004). *Navigating Blackboard: A Student's Guide for Blackboard 6.0 and Blackboard 5.0*. Upper Saddle River: Pearson.
- Strachota, E. (2003). *Student satisfaction in online courses: An analysis of the impact of learner-content, learner-instructor, learner-learner and learner-technology interaction*. Doctoral dissertation, University of Wisconsin-Milwaukee. Ann Arbor, MI: UMI Publishing.
- Suchting, W.A. (1992, Sept.). Constructivism Deconstructed, *Science & Education*, 1 (3), 223-254.
- Surrey School District (2010). From *The Surrey School Board*. Retrieved July 31, 2010, from <http://www.sd36.bc.ca/index.asp>.
- Swan, R. & Mitrani, M., (1993). The changing nature of teaching and learning in computer-based classrooms. *Journal of Research on Computing in Education*, 26, 40-54.
- Takahashi, K., Watanabe, Y., Hoshi, K., Mitsuhashi, S., Matoba, K., & Akahori, K. (2008). Effectiveness of “paper materials (paper) + web” blended learning and special characteristics and effectiveness of paper materials that could be combined with the web. *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2008* (pp. 4429-4434). Chesapeake, VA: AACE.
- Thorne, K. (2003). *Blended Learning: How to Integrate Online and Traditional offline Learning*. London, UK: Kogan Page.
- Trentin, G. (2003). Managing the Complexity of E-Learning Systems. *Educational Technology*, 43 (6), pp. 36-42.
- Trochim, W. (2006). The Research Methods Knowledgebase. Retrieved June 23, 2009 from <http://www.socialresearchmethods.net/kb/quasnegd.htm>
- Uribe, E. (2005). Learner Centered Principles in Distance Education. *Itec.sfsu.edu*. Retrieved May 16, 2009 from http://itec.sfsu.edu/wp/860wp/F05_860_uribe.pdf
- Vilkoniene, M. (2009). Influence of augmented reality technology upon pupils' knowledge about human digestive system: The results of the experiment. *US-China Education Review*, 6 (1), 36-43.
- Virtual School Society (2010). In *Learn Now BC*. Retrieved July 31, 2010, from <http://www.learnnowbc.ca/schools/default.aspx>.
- Vygotsky, L. (1978). *Mind in Society*, London, UK: Harvard University Press.
- Vygotsky, L. (1986). *Thought and Language*, London, UK: Harvard University Press.

- Wackermann, R., Trendel, G., and Fischer, H. E. (2010). Evaluation of a theory of instructional sequences for physics instruction. *International Journal of Science Education*, 32(7), 963-985.
- Waite, J. (2007). Weekly quizzing really works! Online software makes it easy. *Techdirections*, 66 (7), 16-21.
- Wallen, N. E. & Fraenkel, J. R. (2001). *Educational research: A guide to the process*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Watson, J. (2008). *Blended learning: The convergence of online and face-to-face education*. Vienna, VA: The North American Council for Online Learning.
- Wellburn, E. (1996). The Status of Technology in the Education System: A Literature Review. Technology and Distance Education Branch, Ministry of Education, Skills and Training, BC, Canada. Retrieved March 28, 2009 from: http://www.cln.org/lists/nuggets/EdTech_report.html
- Weller, M. (2007). *Virtual Learning Environments: Using, choosing and developing your VLE* - London. Routledge.
- Winch, C. & Gingell, J. (1999). *Key Concepts in the Philosophy of Education*. London, UK: Routledge.
- Wong, D. (2007). A critical literature review on e-learning limitations. *JASA*, 2, 55-62.
- Woo, M.A. & Kimmick, J.V. (2000). Comparison of internet versus lecture instructional methods for teaching nursing research. *Journal of Professional Nursing* 16(3), 132-139.
- Wuensch, K.L. (2005). "What is a Likert Scale and How Do you Pronounce Likert?" East Carolina University. Retrieved July 30, 2010, from <http://core.ecu.edu/psyc/wuenschk/StatHelp/Likert.htm>
- Yatrakis, P.G. & Simon, H.K. (2002). The Effect of Self-selection on Student Satisfaction and Performance in Online Classes. *International Review of Research in Open and Distance Learning*. Retrieved February 24, 2009 from: <http://www.irrodl.org/>
- Young, A. E., & Duhaney, D. C. (2008). Hybrid learning and the principles of good practice in undergraduate education. Retrieved April 21, 2009 from: http://www.itdl.org/Journal/Nov_08/article04.htm
- Young, J. (2007). Interview. *The American Journal of Distance Education*, 20(4), 245-248.
- Young, J. (2002). 'Hybrid' teaching seeks to end the divide between traditional offline and online instruction. *Chronicle of Higher Education*, 48(28), A33. Retrieved March 3, 2009, from EBSCOhost Academic Search Premier.

Yucha, C. & Princen, T. (2000). Insights learned from teaching pathophysiology on the World Wide Web. *Journal of Nursing Education* 39(2), 68-72.

Appendix A: GLOSSARY

Under the main umbrella of distance learning and e-learning, this section presents an overview of concepts and terminology that are found in the literature. The body of literature is growing, and with it uses of terminology that often relate to similar, although not always the same components.

The terms below are referenced in this study.

1. *Distance Education* is defined as learning that takes place in a learning environment where the faculty and students do not meet in a face-to-face setting. It has been described as a process which facilitates learning when the learners are separated from the source of information (Honeyman & Miller, 1993).
2. *Blackboard* is a software system that provides an online course management platform that includes tools for online communication, surveying, and grading. It can be accessed from any computer with Internet access (Spiegel, 2004).
3. *Hybrid or Blended Course* is a course that contains face-to-face components and required online learning components. It refers to a mixing of different learning environments. The phrase may have a range of particular meanings depending on the context in which it is used (Graham, 2005).
4. *Synchronous learning* refers to teacher-student learning that occurs in real time. It is a form of online delivery in which all students are simultaneously present. A time table is required to facilitate this (Moore & Kearsley, 2005).
5. *Asynchronous learning* refers to student learning that occurs independently of any specific time or schedule. This format allows participants to access course

material at their convenience, freeing them from a group schedule.

Communication takes place through message board forums, e-mail and recorded video (Moore & Kearsley, 2005).

6. *A virtual learning environment (VLE)* is a software system designed to support teaching and learning in educational settings. A VLE usually works over the Internet and provides tools such as communication, uploading of content, return of students' work, tracking tools, etc. VLEs were initially designed for use in distance education, but their use has now broadened to support traditional face-to-face classroom activities. This combination is known as Blended Learning (Weller, 2007).
7. *Electronic learning (e-learning)* is a type of technology supported education or learning where the medium of instruction is through computer technology (Nichols, 2008).
8. *ICT (information and communications technology – or technologies)* is an umbrella term that includes any communication device or application encompassing: radio, television, cellular phones, computer and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as videoconferencing and distance learning (Mobile technologies and learning, 2008).
9. *Information technology (IT)*, as defined by the Information Technology Association of America, covers all aspects of computer-based information systems, from study and development to maintenance and management (Delman, 2000).

10. *Distance learning*, an option different from the traditional offline classroom, takes place when space, time, or both separate the teacher and the learner. Whether online through the Internet or videoconferencing, distance learning offers educational opportunities that meet students' changing needs and grant them the flexibility of learning at any time, in any place, and at a pace that meets their individual learning styles. It provides access to learning across barriers of time and distance (Honeyman & Miller, 1993).
11. *A traditional offline course* is a course that is taught entirely face-to-face (F2F) with transmission of information from the teacher to the student.
12. *A hybrid course* is a course with some instructional portion delivered using online platforms, thus reducing face-to-face time when compared to the traditional offline model. It is described by Young (2002) who compares "hybrid" classes with the term "blended" to indicate their dependence on technology and the fact that they substitute virtual meetings for some in-person encounters (Young, 2002).
13. *An Internet-based course* is a course that is taught 100% online with no face-to-face interaction.
14. *Virtual Learning Environment (VLE)* is a term that is frequently used interchangeably with distance learning, online learning, e-learning, or web-based learning.
15. *Virtual Learning Communities (VLC)* create groups defined by a shared educational purpose, rather than classrooms based on physical proximity. They may draw learners from a wide array of locations, and take formal or informal

shape, but they transcend distance through real time communication afforded by technology (Bellah, 1985).

16. *A wiki* is a website that allows users to add and update content on the site using their own web browser. A wiki allows the creation and editing of interlinked web pages through a web browser using a text editor (Mitchell, 2008).
17. *Blogs* are virtual diaries created by individuals and stored on the Internet. The feature that makes them uniquely different from both journals and regular websites is interactive capacity, creating space for visitors to communicate with each other through comment and message widgets (Mutum, Dilip, Wang & Qing, 2010).
18. *A podcast* is a pre-recorded audio program that is posted to a website. The files are downloaded and saved to the user's computer, allowing offline access at will. (Podcast Productions, 2010).
19. *A Likert scale* is a psychometric scale used in questionnaires and in survey research. Responses on a Likert scale are classified according to level of agreement to a statement. A Likert scale is the most common scale in survey research, requiring participants to indicate their level of agreement or disagreement with particular statements (Wuensch, 2005).
20. *Learner-centered* is defined as providing learners greater autonomy and control over choice of subject matter, learning methods and pace of study (Gibbs, 1992).

21. *Active learning* refers to learning that occurs through instructional strategies that engage students intellectually and physically as they pursue given classroom assignments. In the context of science classrooms, students are typically engaged in learning activities such as gathering data, defining issues, stating problems, generating and testing hypotheses, drawing conclusions, and reporting and defending their work (Johnson et al., 2000).

Appendix B: Chemistry 12 Course Outline

CHEMISTRY 12 COURSE OUTLINE

Welcome to Chemistry 12! I hope you enjoy this most interesting course. The purpose of Chemistry 12 is to provide opportunities for students to develop the knowledge, skills, and attitudes necessary for scientific literacy through four major processes: working scientifically, communicating scientifically, using science, and applying science to higher level thinking. Through these processes explored in the course, you should gain independence and learn to take responsibility at the post secondary level.

You might find this course more mathematically challenging than previous science courses. Students must have good math skills and a good background of the major concepts covered in Chemistry 11 before starting Chemistry 12. It is strongly recommended that students have at least 73% or better in Chemistry 11 and Math11 before starting Chemistry 12.

Classroom Guidelines

Students are expected to:

- Attend class on time and be ready to work immediately at the bell
- Be prepared to write a quiz at the beginning of each class
- Be attentive during instructions
- Be responsible in the classroom
- Help classmates work undisturbed
- Complete homework and labs on time
- Maintain a safe work environment
- Be respectful and courteous

Evaluation

Your mark will be calculated as follows:

❖ Tests and Quizzes	40%(70% initially)
❖ Assignments and Labs	30%
❖ Final Exam	30%(0% initially)

Textbook

Hebden: *Chemistry 12: A Workbook For Students*

Students are advised to purchase their own copy (\$25).

Chemistry 12 Study Guide I (Yellow): Assigned

Chemistry 12 Study Guide II (Blue): Assigned

Materials:

- Large 3 ring binder with lined paper and graph paper
- 5 dividers (one for each unit)
- Pencils, pens, felt pens, highlighter, white gum eraser
- 15 cm ruler
- Calculator: A simple scientific calculator

Course Content:

The following topics will be covered during the course:

Unit I – Reaction Kinetics

Safety, reaction rates, properties, controlling rates, homogeneous and heterogeneous reactions, collision theory, kinetic energy and favorable geometry, activated complex, reaction mechanism, activation energy, potential energy diagrams, ΔH , catalysts.

Unit II – Dynamic Equilibrium

Reversible reactions, entropy and enthalpy, Le Chatelier's Principle, shifts in reactions, K_{eq} .

Unit III – Solubility Equilibrium

Ionic and molecular solutions, solubility, equations, K_{sp} , common ion effect.

Midterm Exam

This exam will cover the first three units

Unit IV – Acids, Bases, and Salts

Properties and definitions, Bronsted-Lowry, conjugate acid base pairs, conductivity, strong and weak acids and bases, dissociation, relative strengths, amphiprotic, equilibrium expressions, predicting effects of adding acids or bases, K_a , K_w , K_b , pH, pOH, calculations, salts, hydrolysis, indicators, transition point in titration, buffers, acid rain.

There will be a mid-unit test in this unit.

Unit V – Electrochemistry

Definitions, half and full reactions, relative strengths, spontaneous reactions, balancing reactions, redox titrations, electrochemical cells, reduction potentials, corrosion, electrolytic cells.

Review for Final Exam

Practice provincial exams. The provincial exam is worth 40% of the final mark for the course.

Attendance and Punctuality

You must attend every class on time. Some absences are unavoidable. Get the name and phone number of one or more persons in your class; someone who will be able to tell you what you missed when you were away. You are expected to be in your seat, divider set up, ready to start the daily quiz at the second bell.

Contact Person(s) _____

Phone # _____

Email _____

Please schedule doctor, dentist etc. appointments for times outside of school hours. If you miss a day, you will be missing a large amount of information. Missed quizzes, homework, etc will be assigned a mark of zero unless an acceptable reason (with a note including a phone number) is given. It is the student's responsibility to deal with missed quizzes, homework, etc, on the first day back in the morning before class. Otherwise a mark of zero will be assigned even if a valid reason is given for the absence.

Quizzes

Frequent small quizzes will be given based on work from the previous few day's homework assignments. Late students will be given a mark of zero for the quiz. If you keep up with the homework and see me for extra help whenever you have difficulties, then you should do well on the quizzes.

Tests

A large portion of your mark will come from tests, so it is very important that you are prepared. Students are expected to write their tests on the scheduled date and time.

Homework

Homework will be assigned every day. Chemistry 12 is a very difficult course and requires a large amount of homework. Homework will be assigned every day and must be completed and ready to hand in at the beginning of class the next day (unless I specify an in-class assignment or a later due date). Late homework is worth zero unless a student is absent for a valid reason in which case it is due the first day back.

Labs and Assignments

Chemistry concepts follow a natural order. It is important that you master one level in order to move easily on to the next. Assignments will allow you to test your knowledge and practice the skills you need. Some assignments will be marked in class. The ones that are marked by Ms. Mulji will be collected at the beginning of the class the day that they are due. Any assignments coming in later will be considered late. If you need help on an assignment it is your responsibility to seek help before the assignments are due. You can find me in room 101 throughout the day. On your assignments, be neat and clear and show all the steps you used to arrive at your answer.

Late Labs/ Assignments

Late work will have marks deducted (up to 50%), so please try to have as much done as you can. I will accept late work only until the assignments are handed back to the class.

Assigned Textbooks

Students are responsible for keeping their assigned textbook in excellent condition. Do not write in the textbook or on lab handouts, even in pencil. You will be charged for all pencil, pen, highlighter or other marks, bent or torn pages, water damages or any other damage or loss. The textbook is worth \$50.

Marks and Report Cards

Marks will be posted on the bulletin board and will be updated each week. It is the student's responsibility to check marks for missed work/ quizzes, etc.

Extra Help

If you are having difficulty with any homework or concept, please see me after school. Do not let difficulties pile up and then try to understand everything the night before the test. Getting help for short, frequent periods of time is much better than a few long sessions of help.

Safety

Safety must be foremost on every student's mind. Every student will be required to achieve a mark of 100% on the safety test. Students who do not work safely in the lab will not be allowed to do the lab and will receive a mark of zero for that lab.

Appendix C: Demographic Survey

COMPARING STUDENT ACHIEVEMENT AND SATISFACTION IN TWO CHEMISTRY 12 CLASSROOMS: HYBRID AND TRADITIONAL OFFLINE DELIVERY METHODS – AN IN DEPTH ANALYSIS

DEMOGRAPHIC SURVEY

Survey of Student Demographics and Previous Web-based Learning Experiences

Numeric Identifier: _____

Note: In order to maintain confidentiality, your numerical identifier will not be given to anyone outside of this research study, and will not be revealed to the researchers, until after the course has been completed, and final marks for the course have been submitted.

Instructions

For the purposes of this survey, the terms “hybrid course” involve: (a) face-to-face (FTF) classroom instruction with (b) an electronic online device. Some hybrids use the teacher as a resource and the computer as the main lecturer. In this instance, a significant amount of the learning will occur online through digital means. The teacher will be available to assist with any comprehension or technical/related questions. All assignments, tests, & quizzes will be provided in a paper-based format.

Please fill in one response for each of the questions. For multiple choice questions, circle the letter of your answer.

1. My gender is:
 - a. Male
 - b. Female

2. My age is:
 - a. Under 16
 - b. 16
 - c. 17
 - d. 18
 - e. 19

3. Which of the following statements best describes your previous experiences with Web-based learning?
- a. I have previously taken courses offered on the Web with no face-to-face interactions with the teacher
 - b. I have previously taken courses offered on the Web that have at least one face-to-face interaction with the teacher
 - c. I have previously taken courses offered that consist of a mixture of Web-based lectures and traditional offline lectures with some face-to-face interactions with the teacher
 - d. I have not previously taken any courses offered on the Web
4. Have you taken Chemistry 12 before? (Please note that this includes students who have received **any** prior instruction in Chemistry 12, including students who have not successfully completed the course, and students who are repeating this course to achieve a higher course grade).
- a. I have taken Chemistry 12 previously
 - b. I have not taken Chemistry 12 previously

Appendix D: Introductory Chemistry 12 Activity

In order to achieve success in Chemistry 12, it is necessary to have a strong foundation of the concepts covered in the Chemistry 11 curriculum. Before we begin this course, a good review of these topics is necessary.

Instructions: Complete the following review questions.

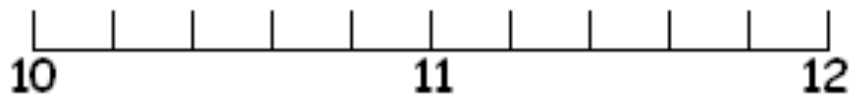
Please note that you will be assessed on this review, therefore a good understanding of all of the questions is necessary in order to ensure success in this course.

Unit Conversions - Multiple Conversions

- 1) Solve the following questions using single or multiple unit conversions. Be sure to include all the steps and the correct units:
 - a) How many seconds are there in 3.8 hours?
 - b) Gold has a density of 19.3 g/cm^3 . What is the volume (in cm^3) of 57.0 g of gold?
 - c) If 0.70 kJ of energy is required to melt 1.00 g of sodium chloride, and $1 \text{ kJ} = 1000 \text{ J}$, how many joules of heat are needed to melt 6.5 kg of sodium chloride?

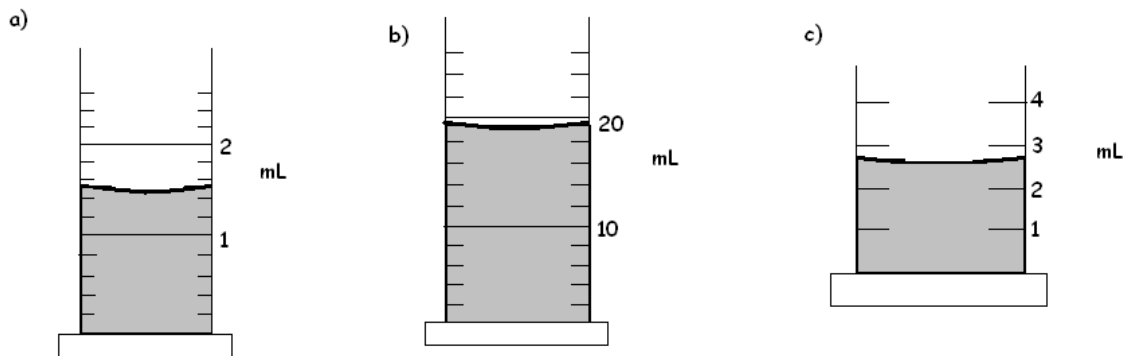
Reading a scale and uncertainty

- 2) Refer to the scale below:



- a) What is the measured reading?
- b) How many significant figures are there in this reading?
- c) How many certain digits are there?
- d) How many uncertain digits are there?

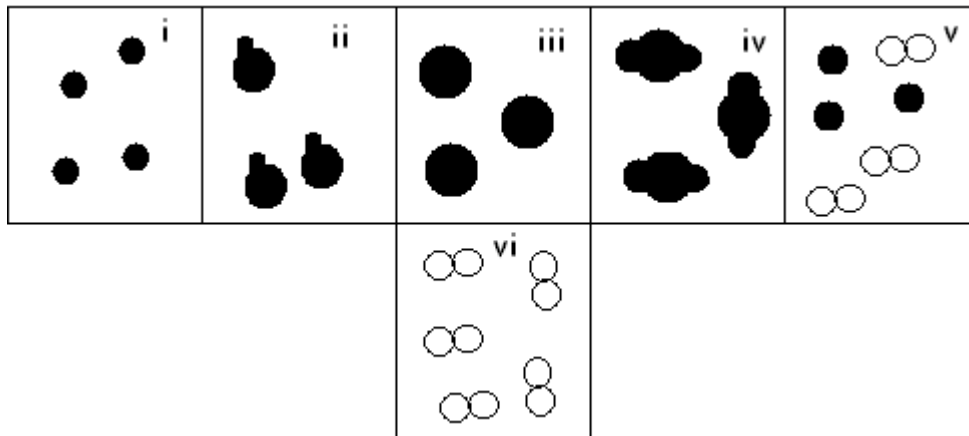
- 3) Determine the volume readings for the following graduated cylinders. State the number of significant figures and the certain/ uncertain digits.



- 4) Match the following particles that make up matter with their correct description:

- | | |
|-------------|--------------------------------------|
| a) Ion | A) The smallest unit of an element |
| b) Atom | B) A charged particle |
| c) Molecule | C) Two or more atoms joined together |

- 5) Using the diagrams below answer the following questions?



- a) Which are mixtures?
 - b) Which are elements?
 - c) Which are compounds?
 - d) Which are molecules?
 - e) In diagrams (i) and (vi), which is Li and which is F?
- 6) Use the words below to match the correct description/classification of matter:
- | | |
|--------------------|---|
| a) Pure Substance | 1) A heterogeneous mixture of liquids and solids |
| b) Qualitative | 2) A solid solution of metals |
| c) Solute | 3) Matter in which the properties are not always the same |
| d) Mixtures | 4) A property of matter which doesn't involve numbers |
| e) Alloy | 5) Matter that always has the same properties |
| f) Molecule | 6) A change where no new substances are formed |
| g) Suspension | 7) The liquid part of a solution |
| h) Emulsion | 8) Smallest particle of an element |
| i) Physical Change | 9) A change where new substances are formed |
| j) Solvent | 10) A suspension which has been treated so parts don't separate |
| k) Chemical Change | 11) When two or more atoms combine |
| l) Atom | 12) The solid part of a solution |
- 7) Write the name or formula for the following ionic compounds containing polyatomic ions:
- a) Na_2SO_4
 - b) Potassium phosphate

- c) Sodium nitrate
- d) KCN
- e) Ca(OH)_2
- f) Tin (IV) sulphate
- g) Ammonium phosphate
- h) NaNO_2
- i) Sodium bicarbonate
- j) Zinc phosphate

8) Name the following covalent compounds using the prefix naming system:

- a) C_2H_6
- b) SO_3
- c) CO
- d) SO_2
- e) NO_2
- f) PCl_5
- g) P_2O_4
- h) NI_3
- i) ClO_2
- j) SF_6

9) Write the name or formula for the following hydrated compounds:

- a) Copper (II) sulphate pentahydrate
- b) $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$
- c) Sodium bromide octahydrate
- d) Sodium sulphate tetrahydrate
- e) $\text{Cr}_3(\text{PO}_4)_2 \cdot 6\text{H}_2\text{O}$

- 10) Write the name or formula for the following acids:
- a) HCl
 - b) Nitrous acid
 - c) Hydrofluoric acid
 - d) HClO_3
 - e) Boric acid
 - f) H_3PO_4
 - g) Sulphuric acid
- 11) The empirical formula of a compound that contains 58.5% C, 7.3% H and 34.1% N is:
- a) $\text{C}_3\text{H}_2\text{N}$
 - b) $\text{C}_2\text{H}_3\text{N}$
 - c) $\text{C}_4\text{H}_6\text{N}_2$
 - d) $\text{C}_2\text{H}_2\text{N}$
- 12) The empirical formula of a compound that contains 46% Li and 54% O is:
- a) Li_2O
 - b) LiO_2
 - c) Li_2O_2
 - d) Li_4O_2
- 13) A substance has a molecular mass of 78.0 g/mol and is 92.3% C and 7.7% H. Its molecular formula is:
- a) CH_6
 - b) C_6H_2
 - c) CH
 - d) C_6H_6

- 14) A molecule has an empirical formula of C_5H_{11} and a molecular mass of 142.32 g/mol. Its molecular formula is:
- a) $C_{10}H_{22}$
 - b) C_5H_{22}
 - c) $C_{11}H_{22}$
 - d) $C_{10}H_{11}$
- 15) When 35.0 g of $FeCl_3$ is dissolved in 550.0 mL of water, the concentration of the resulting solution is:
- a) 0.040 M
 - b) 0.00 M
 - c) 0.40 M
 - d) 4.00 M
- 16) The number of moles of HNO_3 in 400.0 mL of 6.0 M HNO_3 is:
- a) 0.020 moles
 - b) 15.00 moles
 - c) 2400.00 moles
 - d) 2.4 moles
- 17) What volume of 1.75×10^{-1} M KI contains 195.0 g of KI?
- a) 0.20 L
 - b) 6.71 L
 - c) 0.15 L
 - d) 0.0671 mL

- 18) If 30.0 mL of 0.80 M MgS is diluted to a total volume of 250.0 mL, the molar concentration of the resulting MgS solution is:
- a) 0.10 M
 - b) 0.010 M
 - c) 10.0 M
 - d) 0.090 M
- 19) If 275.0 mL of 0.75 M HBr is boiled down (reduced) to a final volume of 150.0 mL, the molarity of HBr in the resulting solution is:
- a) 13.8 M
 - b) 0.410 M
 - c) 1.38 M
 - d) 4.10 M
- 20) If 55.0 mL of 0.200 M PbI_2 is mixed with 45.0 mL of 0.100 M PbI_2 , the concentration of the resulting PbI_2 solution is:
- a) 0.110 M
 - b) 0.050 M
 - c) 0.060 M
 - d) 0.160 M
- 21) Match the following terms with their correct definitions:
- a) Reactants
 - b) Products
 - c) Endothermic Reaction
 - d) Exothermic Reaction
 - e) Absorb Energy
 - f) Release Energy
 - g) Chemical Reactions

- ___ New substances with new properties are formed
- ___ Formation of a new substance after a chemical reaction
- ___ A reaction that absorbs energy
- ___ A reaction that releases energy
- ___ In a chemical reaction, these substances are chemically changed
- ___ Breaking of bonds in a chemical reaction
- ___ Joining and/or rearranging of bands between atoms in a chemical reaction

22) Balance the following equations:

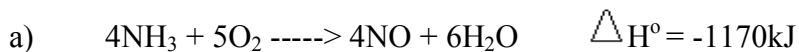
- a) ___ H₂ + ___ O₂ -----> ___ H₂O
- b) ___ CrCl₃ + ___ H₂S -----> ___ Cr₂S₃ + ___ HCl
- c) ___ KClO₃ -----> ___ KCl + ___ O₂
- d) ___ CaO + ___ C -----> ___ CaC₂ + ___ CO₂
- e) ___ NH₃ + ___ H₂SO₄ -----> ___ (NH₄)₂SO₄
- f) ___ Pb(NO₃)₂ + ___ Cu -----> ___ CuNO₃ + ___ Pb

- 23) Write balanced equations for the following word equations. Include subscripts that indicate the phase for each reactant and product.
- Lead (II) nitrate (dissolved in water) plus potassium iodide (dissolved in water) yields solid lead (II) iodide plus potassium nitrate (dissolved in water).
 - Magnesium metal is added to water and yields solid magnesium hydroxide and hydrogen gas.
 - Solid calcium carbonate plus aqueous hydrochloric acid yields aqueous calcium chloride, carbon dioxide gas and water.
 - Sodium chloride (dissolved in water) plus silver nitrate (dissolved in water) yields solid silver chloride and sodium nitrate dissolved in liquid.
- 24) From the following list of reaction types, select the letter that corresponds to each chemical equation:
- Synthesis
 - Decomposition
 - Single Replacement
 - Double Replacement
 - Combustion
 - Acid-base Neutralization
 - No Reaction

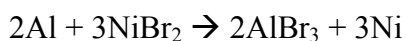
	Chemical Reaction	Type
A	$\text{AgNO}_3 + \text{NaCl} \text{ ----> } \text{AgCl} + \text{NaNO}_3$	
B	$\text{S}_8 + 8\text{Cl}_2 \text{ ----> } 8\text{SCl}_2$	
C	$2\text{NaF} \text{ ----> } 2\text{Na} + \text{F}_2$	
D	$2\text{NaI} + \text{Cl}_2 \text{ ----> } 2\text{NaCl} + \text{I}_2$	
E	$2\text{Mg} + \text{O}_2 \text{ ----> } 2\text{MgO}$	
F	$\text{HCl} + \text{NaOH} \text{ ----> } \text{NaCl} + \text{H}_2\text{O}$	
G	$2\text{C}_2\text{H}_6 + 7\text{O}_2 \text{ ----> } 4\text{CO}_2 + 6\text{H}_2\text{O}$	

H	$2\text{KClO}_3 \text{ -----} > 2\text{KCl} + 3\text{O}_2$	
I	$\text{NH}_3 + \text{H}_2\text{O} \text{ -----} > \text{NH}_4\text{OH}$	
J	$\text{H}_2\text{S} + 2\text{KOH} \text{ -----} > 2\text{H}_2\text{O} + \text{K}_2\text{S}$	

25) Draw and label the enthalpy diagram for the following reactions indicating the reaction type (endothermic or exothermic), the reactants and the products.



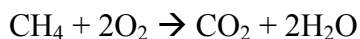
26) Consider the following balanced equation:



How many grams of Ni are produced when 77.9 g of Aluminum reacts with an excess of Nickel (II) bromide?

- a) 2.54 g
- b) 508 g
- c) 169 g
- d) 254 g

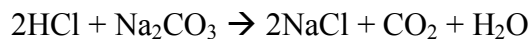
27) Consider the following balanced equation:



What volume of CH_4 at STP is required to produce 24.3 g of H_2O ?

- a) 17.0 g
- b) 15.1 L
- c) 30.2 L
- d) 30.2 g

28) Consider the following balanced equation:



What is the concentration of the HCl solution if 2.0 L of the solution reacts with 16.8 g of Na_2CO_3 ?

- a) 0.16 M
 - b) 16 M
 - c) 160 M
 - d) 0.32 M
- 29) What do we call a substance that is required to completely react with another substance in a chemical reaction:
- a) Excess reactant
 - b) Limiting reactant
 - c) Endothermic reactant
 - d) Theoretical reactant
- 30) In a chemical reaction, mass is neither gained nor lost. The total mass of the reactants equals the total mass of the products. This is known as:
- a) Theoretical mass law
 - b) Mass law
 - c) Conservation of atoms
 - d) Conservation of mass
- 31) In a chemical reaction, the amount of product recovered under lab conditions is known as the:
- a) Percent yield
 - b) Actual yield
 - c) Theoretical yield
 - d) Lab yield

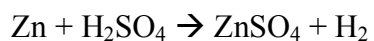
32) In a chemical reaction, the amount of product recovered under perfect conditions is known as the:

- a) Theoretical yield
- b) Actual yield
- c) Percent yield
- d) Lab yield

33) A substance which is not used up entirely in a chemical reaction is known as the:

- a) Limiting reactant
- b) Limiting product
- c) Excess quantity
- d) Actual quantity

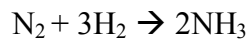
34) Consider the following balanced equation:



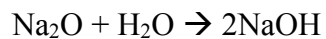
How many moles of ZnSO_4 will be produced if 0.49 mol of Zn reacts with an excess of H_2SO_4 ?

- a) 0.25 mol
- b) 0.98 mol
- c) 0.49 mol
- d) 49 mol

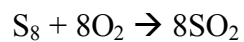
- 35) How many moles of nitrogen are required to react with 6 mol of hydrogen according to the balanced equation:



- a) 6 mol
 - b) 18 mol
 - c) 9 mol
 - d) 2 mol
- 36) How much NaOH is produced from the reaction of 152 g of Na₂O and excess water according to the following balanced equation:



- a) 196 g
 - b) 276 g
 - c) 138 g
 - d) 304 g
- 37) Consider the following reaction at STP:



What volume of oxygen gas is required in order to react with 335 g of sulphur to produce sulphur dioxide?

- a) 235 g
- b) 235 L
- c) 23.5 L
- d) 2.35×10^3 L

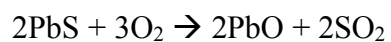
38) How many litres of hydrogen are needed to react with 0.75 mol of oxygen to produce water at STP?

- a) 16.8 L
- b) 33.6 L
- c) 8.40 L
- d) 3.03 g

39) The molar volume of a gas at STP is equal to:

- a) 2.42 L
- b) 2.24 L
- c) 22.4 L
- d) 24.2 L

40) Consider the following equation:



What mass of PbO is produced when 12.8 g of PbS reacts with 8.94 g of O₂?

- a) 11.9 g
- b) 41.5 g
- c) 124 g
- d) 23.9 g

- 41) Calculate the number of neutrons, protons and electrons for the following atoms or ions:

Isotope	Atom/Ion	Charge	Mass #	Atomic #	# p	# e-	# n
${}^2_1\text{H}$	Atom	0	2	1			
${}^{55}_{25}\text{Mn}^{2+}$	Ion	+2	55	25			
${}^{14}_6\text{C}$	Atom	0	14	6			
${}^{58}_{26}\text{Fe}^{2+}$	Ion	+2	58	26			
${}^{31}_{16}\text{S}^{2-}$	Ion	-2	31	16			

Periodic Table of the Elements

IA																	O				
1	H															He					
IIA																IIIA		IVA	VIA	VIIA	
2	Li	Be											B	C	N	O	F	Ne			
3	Na	Mg	III B	IV B	VB	VIB	VII B	VII		IB	IIB	Al	Si	P	S	Cl	Ar				
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr			
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe			
6	Cs	Ba	*La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn			
7	Fr	Ra	+Ac	Rf	Ha	Sg	Ns	Hs	Mt	110	111	112	113								

* Lanthanide Series

+ Actinide Series

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

42) Using the above periodic table, answer the following questions:

- a) Where do we find the metals?
- b) Where do we find the non-metals?
- c) Where do we find the metalloids?
- d) Where do we find the alkali metals?
- e) Where do we find the alkaline earth metals?
- f) Where do we find the halogens?
- g) Where do we find the noble gases?

43) Identify the noble gas from the following list.

- a) Ba c) Xe
- b) K d) C

44) Using the points listed below about conductivity of substances, state whether the substances will or will not conduct.

Metals will conduct electricity

An electrolyte is an aqueous solution that will conduct electricity

Non-electrolyte is an aqueous solution that will not conduct electricity

Ionic compounds are electrolytes (these include acids, bases, and salts)

Covalent compounds are non electrolytes

Substance	Conduction (Y or N)	Substances	Conduction (Y or N)
NaOH (aq)		I ₂ (q)	
HCl (aq)		NaCl (s)	
Cu (s)		Cl ₂ (g)	

Fe (s)		Ne (g)	
NaCl (aq)		Co (s)	
H ₂ O (l)		KNO ₃ (aq)	

45) Write ionization equations when the following ionic solids dissolve forming aqueous solution:

- a) KI
- b) NaCl
- c) FeSO₄
- d) AlPO₄
- e) NaOH

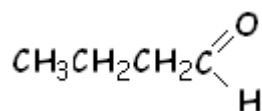
46) Write ionization or dissolving equations when the following substances are introduced in solution:

- a) LiOH (s)
- b) HNO₃ (aq)
- c) Br₂ (l)
- d) C₆H₁₂O₆ (s)
- e) C₂H₅OH (l)

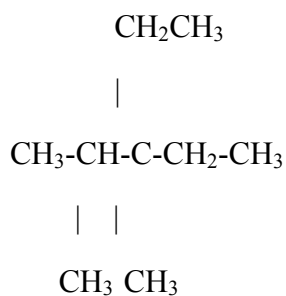
47) Calculate the concentration of each ion in the following solutions given the molarity of the solutions:

- a) 0.25 M KCl
- b) 0.50 M HClO₄
- c) 1.0 M Al₂(SO₃)₃

- 48) What is the concentration of each type of ion in a solution made by mixing 50.0 mL of 0.300 M CaCl_2 and 75.0 mL of a 0.200 M MgCl_2 ?
- 49) What is the concentration of each type of ion in a solution made by mixing 25.0 mL of 0.100 M NaBr and 80.0 mL of 0.250 M SrBr_2 ?
- 50) What is the concentration of each type of ion in a solution made by mixing 2.5 L of 1.5 M Na_2SO_4 and 1.8 L of 2.2 M NaI ?
- 51) The type of organic compound shown below is a:

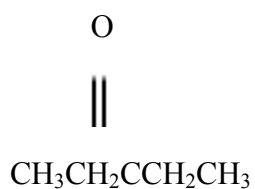


- a) Ketone
- b) Carboxylic acid
- c) Aldehyde
- d) Ester
- 52) What is the name of the following compound:

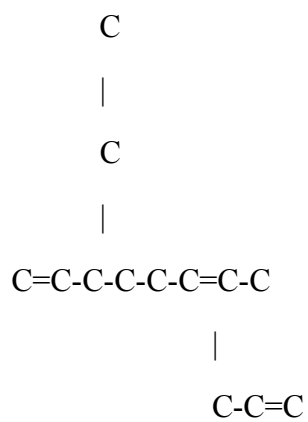


- a) 2-methyl-3-ethyl hexane
- b) 2-methyl-3,3-diethylbutane
- c) 3-methyl-2,3-dimethylpentane
- d) 3-ethyl-2,3-dimethylpentane

53) The correct name for the following compound is:



- a) 3-pentanone
 - b) 3-pentanal
 - c) 3-pentanol
 - d) 3-hexanone
- 54) How many hydrogen atoms are required in order to complete the following:



- a) 20
- b) 22
- c) 21
- d) 23

55) The type of organic compound shown below is a:

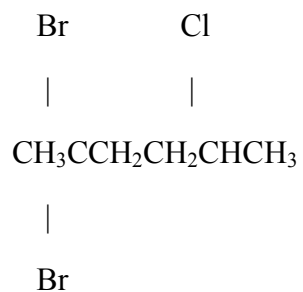


- a) Ester
- b) Alcohol
- c) Aldehyde
- d) Ketone

56) An organic compound with the formula $\text{R} - \text{O} - \text{R}$ is a:

- a) Amide
- b) Ester
- c) Ether
- d) Amine

57) What is the correct name for the following compound:

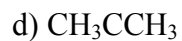
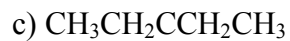
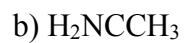


- a) 2-bromo-5-chlorohexane
- b) 2,2-dibromo-5-chlorohexane
- c) 2,2-dibromo-3-chloroheptane
- d) 5,5-dibromo-3-chlorohexane

58) The correct name for the following compound is:



- a) ethyl hexanoate
 - b) hexyl ethanoate
 - c) propyl pentanoate
 - d) pentyl propanoate
- 59) Which of the following compounds is an amine:



60) The correct name for the following compound is:



- a) Methyether butane
- b) Methyethanoic acid
- c) Butylmethane ether
- d) 1-Methoxybutane

Appendix E: Pre-Assessment

Are You Ready For Chemistry 12?

- 1) 0.00776 mL is equal to how many litres?
 - a) 7.76×10^{-3} L
 - b) 7.76×10^{-6} L
 - c) 7.76×10^6 L
 - d) 7.76×10^3 L

- 2) When you convert 8.5 kg to grams, the answer is:
 - a) 8.5×10^3 g
 - b) 8.5×10^{-3} g
 - c) 850 g
 - d) 85 000 g

- 3) Perform the following calculation: $98.245 \times 2.2 =$
(Using the correct number of significant figures)
 - a) 216
 - b) 220.0
 - c) 216.139
 - d) 220

4) Perform the following calculation: $797.2 / 1.23$
(Using the correct number of significant figures)

- a) 640
- b) 600
- c) 648
- d) 650

5) The SI unit for amount of substance is:

- a) mol
- b) g
- c) Kg
- d) g/mol

6) The SI unit for mass of a substance is:

- a) mol
- b) Kg
- c) amu
- d) L

7) The metric prefix for 1/1000 is

- a) deci
- b) milli
- c) centi
- d) kilo

- 8) How many grams of MgCl_2 are required in order to prepare 250.0 mL of a 1.00 M solution?
- a) 3.81×10^{-1} g
 - b) 3.81×10^2 g
 - c) 2.38×10^4 g
 - d) 23.8 g
- 9) How many grams of Ca(OH)_2 are in 500 mL of a 2.0 M Ca(OH)_2 solution?
- a) 74 g
 - b) 7.4×10^4 g
 - c) 4.0 g
 - d) 0.004 g
- 10) What is the total concentration of all the ions in solution when $\text{Al(NO}_3)_3$ is dissolved in water to form a 0.55 M solution?
- a) 0.55 M
 - b) 0.18 M
 - c) 2.20 M
 - d) 0.17 M
- 11) The most concentrated solution from the list below is:
- a) 300 mL of 0.20 M HCl (aq)
 - b) 250 mL of 1.50 M CaCl_2 (aq)
 - c) 50 mL of 0.10 M NaOH (aq)
 - d) 850 mL of 0.010 M CuSO_4 (aq)

- 12) The concentration of NaBr, if 0.075 moles is dissolved to produce 75.0 mL of solution is:
- a) 0.075 M
 - b) 10.0 M
 - c) 1.00 M
 - d) 0.001 M
- 13) The number of moles in 150.0 mL of 2.00 M solution is:
- a) 300 mol
 - b) 0.013 mol
 - c) 13.3 mol
 - d) 0.300 mol
- 14) How many moles are there in 500.0 mL of 2.50 M HCl solution?
- a) 0.200 mol
 - b) 5.00 mol
 - c) 0.005 mol
 - d) 1.25 mol
- 15) What volume of 0.200 M solution of Ba(OH)₂ is needed to produce 1.50 g of Ba(OH)₂?
- a) 0.133 L
 - b) 438 L
 - c) 4.38×10^{-2} L
 - d) 4.38×10^{-1} L

- 16) What volume of 12.0 M HCl is needed to prepare 1.00 L of a 1.00 M solution?
- a) 0.083 L
 - b) 83.0 L
 - c) 0.0083 L
 - d) 830.0 L
- 17) 75.0 mL of 1.0 M FeCl₃ is diluted to a final volume of 200.0 mL. The new concentration of FeCl₃ is:
- a) 3.8 M
 - b) 0.38 M
 - c) 2.7 M
 - d) 0.27 M
- 18) Select the substance which is most basic with respect to its pH:
- a) salt
 - b) lemon juice
 - c) bathroom cleaner
 - d) vinegar
- 19) Select the substance which is most acidic with respect to its pH:
- a) lemon juice
 - b) oven cleaner
 - c) concentrated sodium hydroxide solution
 - d) salt

- 20) $\text{HCl (aq)} + \text{NaOH (aq)} \rightarrow \text{NaCl (s)} + \text{H}_2\text{O}$, is an example of what type of reaction?
- a) single replacement
 - b) hydrolysis
 - c) decomposition
 - d) neutralization
- 21) A solution in which no more solute can be dissolved is said to be:
- a) saturated
 - b) unsaturated
 - c) miscible
 - d) indissolveable
- 22) Hydrocarbon combustion is an example of what type of reaction?
- a) decomposition
 - b) synthesis
 - c) neutralization
 - d) double replacement
- 23) $\text{KBr(aq)} \rightarrow \text{K}^+ \text{(aq)} + \text{Br}^- \text{(aq)}$, is an example of what type of reaction?
- a) single replacement
 - b) acid/ base neutralization
 - c) synthesis
 - d) decomposition

- 24) When oil is added to water, the two substances do not dissolve in each other. This is an example of:
- a) both b and c
 - b) an immiscible solution
 - c) a soluble solution
 - d) a miscible solution
- 25) What is the concentration of a solution that is made up of 2.93×10^{26} formula units of NaOH, dissolved in 2.50 L of water?
- a) 0.005 M
 - b) 195 M
 - c) 0.195 M
 - d) 12.20 M
- 26) What is the concentration of 0.989 g of KI dissolved in 75.0 mL of water?
- a) 4.47×10^{-4} M
 - b) 0.0795 M
 - c) 0.447 M
 - d) 1.26×10^1 M
- 27) What volume of water is required to dilute 400.0 mL of 6.0 M NaNO₃ to a concentration of 1.5 M?
- a) 1200 mL
 - b) 0.01 mL
 - c) 16 000 mL
 - d) 0.001 mL

- 28) What is the dissociation equation for $\text{Cu}(\text{SO}_4)$ aq?
- a) $\text{Cu}(\text{SO}_4) (\text{aq}) \rightarrow 2 \text{Cu}^+ (\text{aq}) + \text{SO}_4^- (\text{aq})$
 - b) $\text{Cu}(\text{SO}_4) (\text{aq}) \rightarrow 2 \text{Cu}^+ (\text{aq}) + 2\text{SO}_4^{2-} (\text{aq})$
 - c) $\text{Cu}(\text{SO}_4) (\text{aq}) \rightarrow \text{Cu}^{2+} (\text{aq}) + \text{SO}_4^{2-} (\text{aq})$
 - d) $\text{Cu}(\text{SO}_4) (\text{aq}) \rightarrow \text{Cu} (\text{aq}) + \text{SO}_4 (\text{aq})$
- 29) After balancing the following equation, the coefficients, in order, from left to right are:
- $$\underline{\quad} \text{NH}_3 + \underline{\quad} \text{O}_2 \rightarrow \underline{\quad} \text{NO}_2 + \underline{\quad} \text{H}_2\text{O}$$
- a) 8, 7, 8, 12
 - b) 2, 3, 2, 3
 - c) 4, 7, 4, 6
 - d) 4, 8, 4, 6
- 30) How many molecules are there in 10.8 g of oxygen gas?
- a) 2.03×10^{23} molecules
 - b) 1.27×10^{23} molecules
 - c) 6.72 molecules
 - d) 1.27 molecules
- 31) 4.59 g of chlorine gas occupies what volume at STP?
- a) 22.4 L
 - b) 3.86×10^{22} L
 - c) 1.44 L
 - d) 2.87 L

- 32) How many oxygen atoms are there in a 5.5 g sample of SO_3 ?
- a) 4.1×10^{22} oxygen atoms
 - b) 1.2×10^{23} oxygen atoms
 - c) 2.1×10^{23} oxygen atoms
 - d) 1.5×10^{23} oxygen atoms
- 33) What is the percentage by mass of sodium and fluorine in NaF?
- a) Na: 54.76%, F: 45.24%
 - b) Na: 1%, F: 1%
 - c) Na: 50%, F: 50%
 - d) Na: 23%, F: 18%
- 34) What is the mass of 1.22×10^{25} molecules of sulphur dioxide?
- a) 1.30 Kg
 - b) 1.30 g
 - c) 1.30×10^3 Kg
 - d) 1.30×10^3 g
- 35) Find the molecular formula for a compound that is composed of 9.6 g of oxygen, 7.2 g of carbon, and 1.2 g of hydrogen given that the molar mass of this compound is 180.0 g
- a) $\text{C}_6\text{H}_{12}\text{O}_6$
 - b) CH_2O
 - c) CHO_2
 - d) $\text{C}_6\text{H}_6\text{O}_6$

- 36) What is the percent of carbon in ethane?
- a) 30%
 - b) 80.0%
 - c) 12.0%
 - d) 70.0%
- 37) What is the molar mass of Copper (I) Sulphate?
- a) 223 g/mol
 - b) 160 g/mol
 - c) 95.5 g/mol
 - d) 955 g/mol
- 38) How many moles of hydrogen gas are required to react with an excess of nitrogen gas to produce 0.89 mol of ammonia?
- a) 0.59 mol
 - b) 1.3 mol
 - c) 0.89 mol
 - d) 3.0 mol
- 39) Consider the following unbalanced equation:
- $$\text{Mg(s)} + 2\text{HCl (aq)} \rightarrow \text{H}_2 \text{ (g)} + \text{MgCl}_2 \text{ (s)}$$
- What volume of 2.00 M HCl is needed to react with 1.54 g of magnesium?
- a) 0.0317 L
 - b) 2.54 L
 - c) 0.0634 L
 - d) 3.17 L

40) Consider the following reaction:



If 25.8 g of Cu are reacted with 38.3 g of HNO₃, which reactant is present in excess?

- a) copper
- b) hydrogen
- c) nitric acid
- d) Copper (II) nitrate

41) What is the mass number of nitrogen?

- a) 14
- b) 15
- c) 7
- d) 8

42) What is the atomic number of Cr?

- a) 6
- b) 24
- c) 52
- d) 28

43) What is the average atomic mass given the following relative abundance of each isotope for the element:

- | | |
|---------------------------|--------------------------------|
| ⁴⁰ Ca- 96.97% | a) 2.0 x 10 ¹ g/mol |
| ⁴² Ca- 0.64% | b) 400 g/mol |
| ⁴³ Ca- 0.145% | c) 0.400 g/mol |
| ⁴⁴ Ca- 2.06% | d) 4.0 x 10 ¹ g/mol |
| ⁴⁶ Ca- 0.0033% | |
| ⁴⁸ Ca- 0.18% | |

- 44) Ionization energy can be described by which of the following?
- a) energy added to an atom for bonding
 - b) energy required to remove an electron from a neutral atom
 - c) energy that holds two atoms together
 - d) energy required to add an electron to a neutral atom
- 45) What is the periodic table trend for electronegativity?
- a) decreases left to right and bottom to top
 - b) increases left to right and decreases bottom to top
 - c) increase left to right and bottom to top
 - d) decreases left to right and increases bottom to top
- 46) What is the general trend for the atomic radius of elements as you move across a period from left to right?
- a) decreases from left to right and from bottom to top
 - b) increases from left to right and from bottom to top
 - c) decreases from left to right and increases from bottom to top
 - d) increases from left to right and from top to bottom
- 47) What are the group 2 elements called?
- a) halogens
 - b) alkaline earth metals
 - c) alkali metals
 - d) noble gases

- 48) What are the group 17 elements called?
- a) Halogens
 - b) Transition Elements
 - c) Metalloids
 - d) Noble Gases
- 49) What is the name of the element that is in period 4 and group 2
- a) bromine
 - b) silicon
 - c) zirconium
 - d) calcium
- 50) Alkynes are hydrocarbons that contain:
- a) no bonds
 - b) double bonds
 - c) single bonds
 - d) triple bonds

Appendix F: Post-Assessment

REACTION KINETICS UNIT ASSESSMENT

Multiple Choice Questions

Record all answers on the answer sheet provided

Good Luck!!!

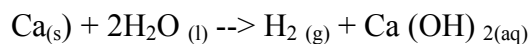
1. A student decomposes 50mL of bleach and collects the oxygen produced in a gas collection tube. The total volume of oxygen is measured every 10 seconds.

Time (seconds)	Volume (O ₂)
0	0.0
10.0	5.2
20.0	9.8
30.0	13.6
40.0	16.5

What is the average reaction rate between 10.0 and 20.0 seconds?

- A. 0.41 mL/s
- B. 0.46 mL/s
- C. 0.50 mL/s
- D. 1.2 mL/s

2. Consider the following reaction in a closed system:



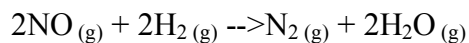
In order to determine the reaction rate, which would be the best property to monitor?

- A. Volume of H₂
- B. Surface area of Ca
- C. Pressure of Ca(OH)₂
- D. Concentration of H₂O

Use the following factors that affect reaction rates to answer questions 3 and 4.

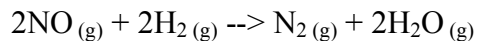
I.	Temperature
II.	Concentration
III.	Nature of Reactants
IV.	Catalysts
V.	Surface area

3. Which factors could be used to increase the rate of the following reaction?



- A. III, V
- B. I, II, IV
- C. I, II, IV, V
- D. I, II, III, V

4. Which factors could be changed to increase the fraction of successful collisions in the following reaction?



- A. I, IV
- B. III, V
- C. I, II, IV
- D. I, II, IV, V

Use the following reaction mechanism to answer question 5 and 6

Step 1	$\text{NO} + \text{O}_2 \rightarrow \text{OONO}$
Step 2	$\text{NO} + \text{OONO} \rightarrow 2\text{NO}_2$
Overall	$2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$

5. What substance is missing in step 2?

Substance missing
A. O ₂
B. NO
C. NO ₂
D. OONO

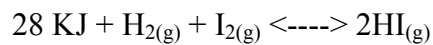
6. Which of the following substances could represent an activated complex from the above mechanism?

Activated Complex
A. O ₂
B. NO
C. NO ₂
D. N ₂ O ₄

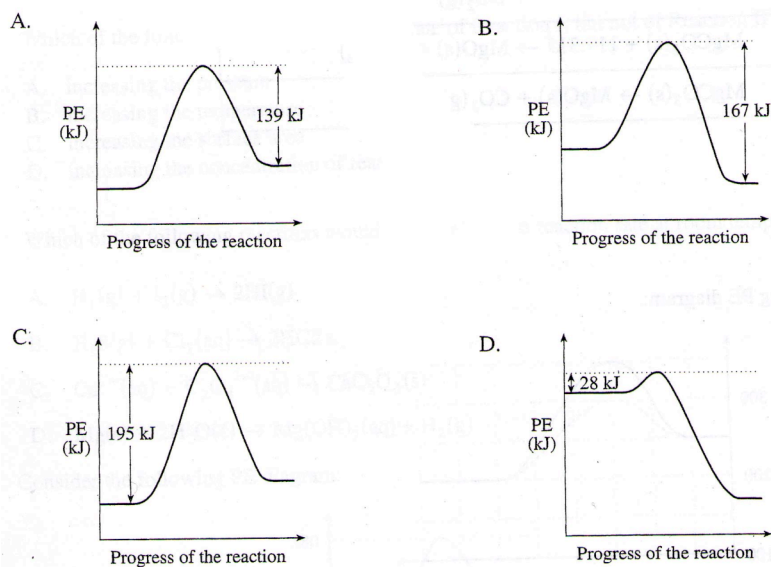
7. Which factor affects the reaction rate of heterogeneous reactions, but not homogeneous reactions?

- A. Catalyst
- B. Temperature
- C. Surface area
- D. Concentration

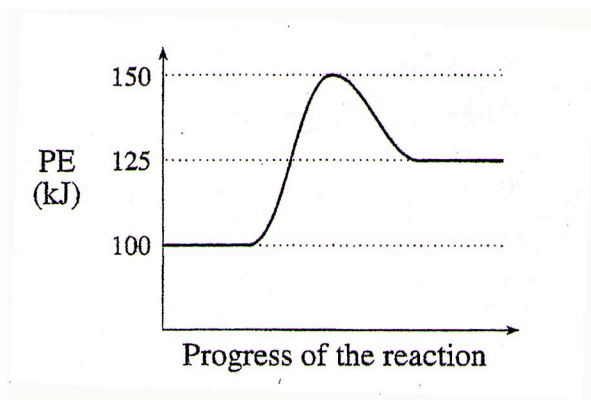
8. The following forward reaction has an $E_a = 167\text{KJ}$:



Which of the PE diagrams below represents this reaction?



9. Consider the following PE diagram:



Which of the following is true for the forward reaction?

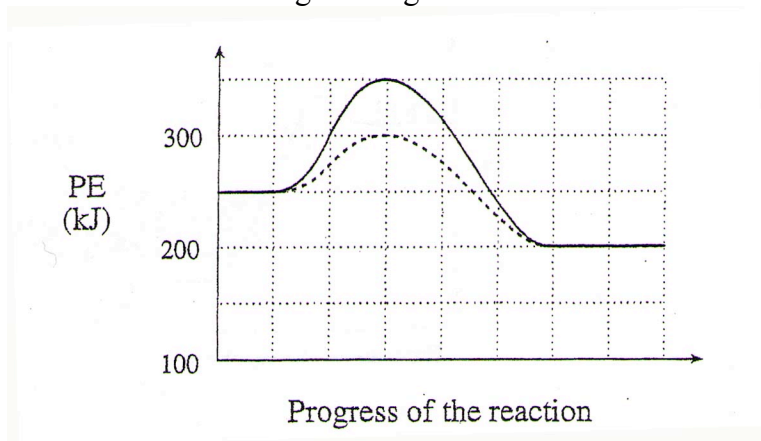
ΔH (KJ)	PE of Activated Complex(KJ)
A. -25	50
B. -25	150
C. +25	50
D. +25	150

1. When one mole of MgCO_3 decomposes, 117.3KJ of energy is absorbed. Which of the following describes this reaction?

I.	$\text{MgCO}_{3(s)} \rightarrow \text{MgO}_{(s)} + \text{CO}_{2(g)} \quad \Delta H = +117.3\text{KJ}$
II.	$\text{MgCO}_{3(s)} \rightarrow \text{MgO}_{(s)} + \text{CO}_{2(g)} \quad \Delta H = -117.3\text{KJ}$
III.	$\text{MgCO}_{3(s)} + 117.3\text{KJ} \rightarrow \text{MgO}_{(s)} + \text{CO}_{2(g)}$
IV.	$\text{MgCO}_{3(s)} \rightarrow \text{MgO}_{(s)} + \text{CO}_{2(g)} + 117.3\text{KJ}$

- A. I only
 B. IV only
 C. I and III
 D. II and IV

2. Consider the following PE diagram:



Which of the following is true for the reverse reaction?

	ΔH	E_a
A. Catalyzed	-50KJ	100KJ
B. Catalyzed	50KJ	150KJ
C. Uncatalyzed	-50KJ	100KJ
D. Uncatalyzed	+50KJ	150KJ

3. In an exothermic reaction, what energy changes occur when reactant bonds are broken and product bonds are formed?

Breaking Reactant bonds	Forming Product Bonds
A. Energy is released.	Energy is released.
B. Energy is released.	Energy is absorbed.
C. Energy is absorbed.	Energy is absorbed.
D. Energy is absorbed.	Energy is released.

4. Consider the following Reactions:

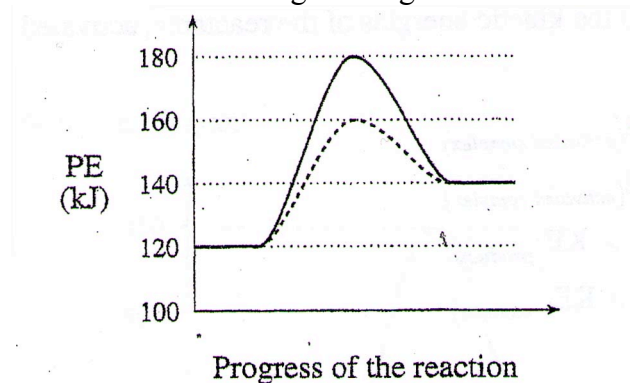
Reaction I	$2\text{As}_{(s)} + 3\text{Cl}_{2(g)} \rightarrow 2\text{AsCl}_{3(l)}$
Reaction II	$\text{PCl}_{3(g)} + \text{Cl}_{2(g)} \rightarrow \text{PCl}_{5(g)}$

Which of the following would increase the rate of Reaction I, but not of Reaction II?

- A. Increasing the pressure
 B. Increasing the temperature
 C. Increasing the surface area
 D. Increasing the concentration of reactants
5. Which of the following reactions would have the highest reaction rate at room temperature?

- A. $\text{H}_{2(g)} + \text{I}_{2(g)} \rightarrow 2\text{HI}_{(g)}$
 B. $\text{H}_2\text{S}_{(g)} + \text{Cl}_{2(aq)} \rightarrow 2\text{HCl}_{(aq)} + \text{S}_{(s)}$
 C. $\text{Ca}^{2+}_{(aq)} + \text{C}_2\text{O}_4^{2-}_{(aq)} \rightarrow \text{CaC}_2\text{O}_{4(s)}$
 D. $\text{Mg}_{(s)} + 2\text{H}_2\text{O}_{(l)} \rightarrow \text{Mg}(\text{OH})_{2(aq)} + \text{H}_{2(g)}$

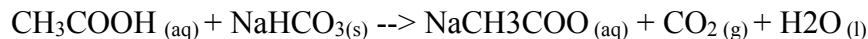
6. Consider the following PE diagram:



Which of the following is the activation energy of the forward catalyzed reaction?

- A. 20kJ
 B. 40 kJ
 C. 60kJ
 D. 160kJ

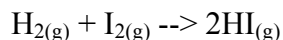
7. Consider the following reaction:



Which of the following properties could best be used to measure the reaction rate?

- A. The volume of CO_2
- B. The volume of H_2O
- C. The mass of CH_3COOH
- D. The surface area of NaHCO_3

8. Consider the following reaction:



Which of the following is true of the activated complex relative to the reactants?

KE	Stability
A. High	Stable
B. Low	Stable
C. High	Unstable
D. Low	Unstable

9. Which of the following could describe a catalyst?

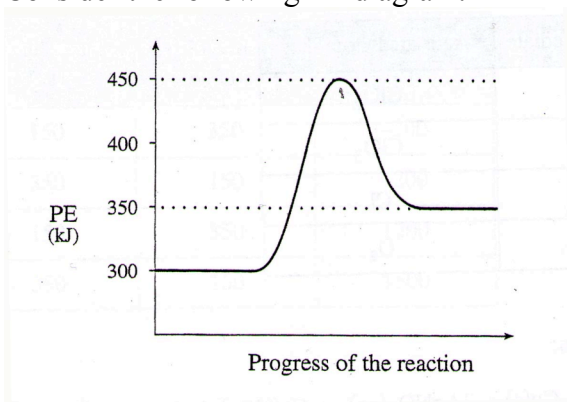
- A. A substance that increase the reaction time
- B. A substance that provides an alternate mechanism with a higher activation energy
- C. A substance that is formed in one step and used up in a subsequent step in a reaction mechanism
- D. A substance that is used up in one step and reformed in a subsequent step in a reaction mechanism

10. For an endothermic reaction, how do the kinetic energies of the reactants, activated complex and products compare?

- A. $\text{KE}(\text{reactants}) > \text{KE}(\text{products}) > \text{KE}(\text{activated complex})$
- B. $\text{KE}(\text{products}) > \text{KE}(\text{reactants}) > \text{KE}(\text{activated complex})$
- C. $\text{KE}(\text{activated complex}) > \text{KE}(\text{reactants}) > \text{KE}(\text{products})$
- D. $\text{KE}(\text{activated complex}) > \text{KE}(\text{products}) > \text{KE}(\text{reactants})$

11. Consider the following reaction:
$$\text{Zn}_{(s)} \rightarrow 2\text{HCl}_{(aq)} \rightarrow \text{ZnCl}_{2(aq)} + \text{H}_{2(g)}$$
- Which of the following would increase the reaction rate?
- A. An increase in pressure
 - B. An increase in temperature
 - C. An increase in the concentration of H_2
 - D. An increase in the concentration of ZnCl_2
12. Which of the following reactions is most likely to occur in one-step?
- A. $\text{H}_{2(g)} + \text{I}_{2(g)} \rightarrow 2\text{HI}_{(g)}$
 - B. $\text{N}_{2(g)} + 2\text{H}_{2(g)} \rightarrow 2\text{NH}_{3(g)}$
 - C. $2\text{NO}_{(g)} + \text{O}_{2(g)} \rightarrow 2\text{NO}_{2(g)}$
 - D. $\text{Cl}_{2(g)} + 2\text{NO}_{(g)} \rightarrow 2\text{NOCl}_{(g)}$
13. Which of the following describes the relationship between activation energy and reaction rate?
- A. Increasing E_a increases reaction rate
 - B. Decreasing E_a increases reaction rate
 - C. Decreasing E_a decreasing reaction rate
 - D. Increasing E_a does not affect the reaction rate
14. Which of the following could represent the units for reaction rate?
- A. g/mL
 - B. g/ min
 - C. g/ mol
 - D. mol/ L
15. Consider the following reaction:
$$2\text{Al}_{(s)} + 3\text{CuCl}_{2(aq)} \rightarrow 3\text{Cu}_{(s)} + 2\text{AlCl}_{3(aq)}$$
- If 0.56g Cu is produced in 1.0 minute, what mass of Al is used up in 20.0 seconds?
- A. 0.053g
 - B. 0.12g
 - C. 0.16g
 - D. 0.37g

16. Consider the following PE diagram:



Which of the following correctly describes the forward reaction?

Reaction type	ΔH (KJ)
A. Exothermic	-50
B. Exothermic	-100
C. Endothermic	+50
D. Endothermic	+100

17. Which of the following correctly describes the relationship between the activation energy of a reaction and the rate of the reaction?

	E_a	Rate
I.	Increases	Increases
II.	Increases	Decreases
III.	Decreases	Decreases
IV.	Decreases	Increases

- A. I only
- B. IV only
- C. I and III only
- D. II and IV only

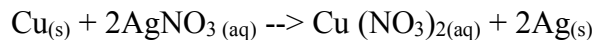
18. Consider the reaction mechanism:

Step 1	$\text{Cl} + \text{O}_3 \rightarrow \text{O}_2 + \text{ClO}$
Step 2	$\text{O}_3 \rightarrow \text{O}_2 + \text{O}$
Step 3	$\text{ClO} + \text{O} \rightarrow \text{Cl} + \text{O}_2$

Which of the following represent a reaction intermediate and an activated complex?

Reaction intermediate	Activated Complex
A. O	ClO ₂
B. O ₂	ClO ₃
C. ClO	Cl
D. ClO	O ₂

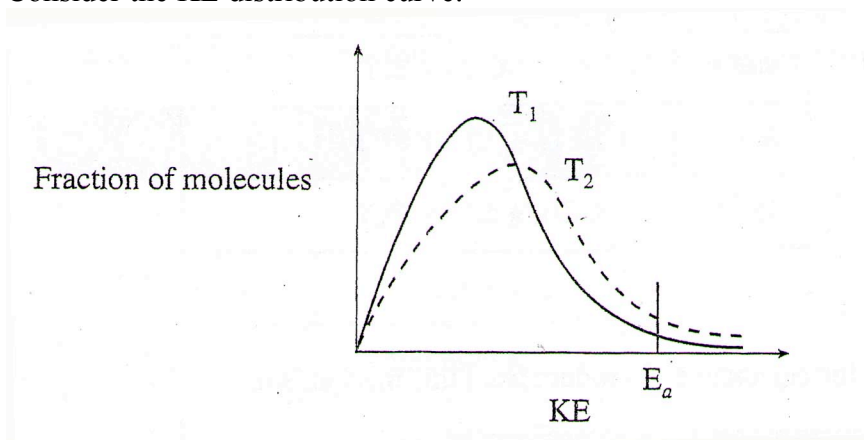
19. Consider the reaction:



When 1.42g of Cu is placed in 1.0M AgNO₂ at 30°C, some of the Cu reacts. As a result, 0.42g of Ag is produced in 4.0min. What is the rate of this reaction?

- A. $1.3 \times 10^{-1} \text{ }^\circ\text{C/s}$
- B. $4.2 \times 10^{-3} \text{ M/s}$
- C. $5.9 \times 10^{-3} \text{ g Cu/s}$
- D. $1.8 \times 10^{-3} \text{ g Ag/s}$

20. Consider the KE distribution curve:



Which of the following explains why a higher temperature speeds up a reaction?

- A. When temperature is increased to T₁ KE = E_a
- B. When temperature is increased to T₂, the E_a is increased
- C. When temperature is increased to T₁, a larger fraction of molecules has the required energy to react
- D. When temperature is increased to T₂, a larger fraction of molecules has the required energy to react.

21. Which of the following set of values is consistent with a reversible reaction?

$E_{a(\text{forward})}$ (KJ)	$E_{a(\text{reverse})}$ (KJ)	$\Delta H_{(\text{forward})}$ (KJ)
A. 150	350	-200
B. 350	150	-200
C. 150	350	+200
D. 350	150	+500

22. Consider the reaction:



If the system is closed, which of the following properties could NOT be used to measure the rate of this reaction?

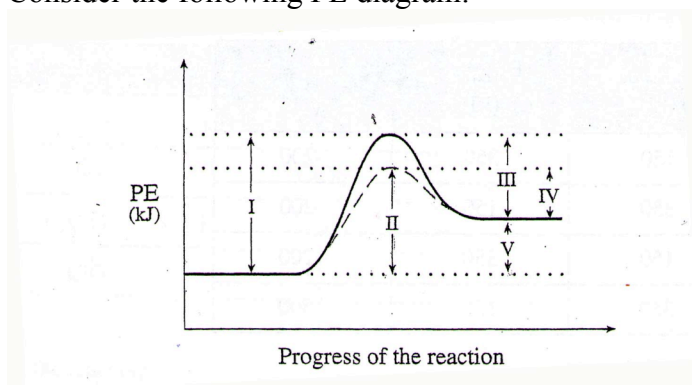
- A. pH
 - B. pressure
 - C. mass of the system
 - D. electrical conductivity
23. Consider the following reaction mechanism:

Step 1	$\text{Cl}_2 \rightarrow 2\text{Cl}$
Step 2	$\text{CHCl}_3 + \text{Cl} \rightarrow \text{HCl} + \text{CCl}_3$
Step 3	$\text{CCl}_3 + \text{Cl} \rightarrow \text{CCl}_4$

Identify a reaction intermediate and product from this mechanism.

Reaction Intermediate	Product
A. Cl	CCl_3
B. Cl	HCl
C. Cl_2	CCl_4
D. CCl_3	CHCl_4

24. Consider the following PE diagram:



Which of the following is true for the forward reaction?

Ea(Catalyzed)	ΔH
A. I	III
B. I	V
C. II	IV
D. II	V

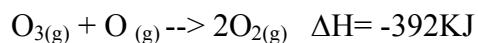
25. When 2 molecules of N_2O collide, they react and form 2 molecules of N_2 and 1 molecule of O_2 . Which of the following correctly describes the activated complex?

Formula	Kinetic Energy
A. N_2O_2	Minimum KE
B. N_2O_2	Maximum KE
C. N_4O_2	Minimum KE
D. N_4O_2	Maximum KE

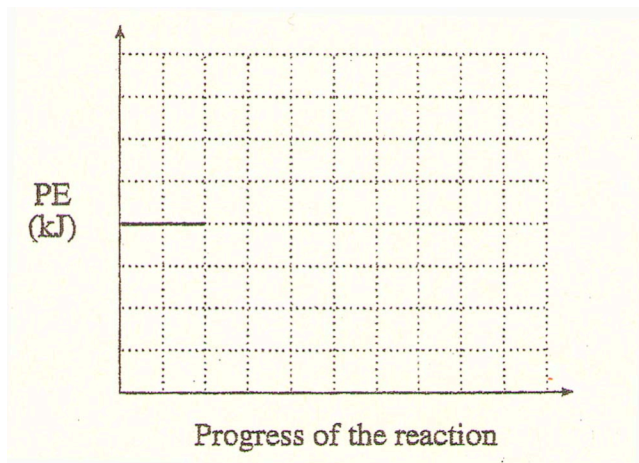
Written Response

Use the following information to answer questions 1 and 2.

Ozone (O_3) is destroyed in the upper atmosphere in a one-step mechanism according to the following equation.



1. Sketch a PE diagram for this reaction. (Exact values are not required.) Label ΔH and E_a . (2marks)

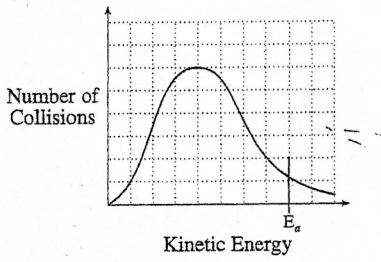
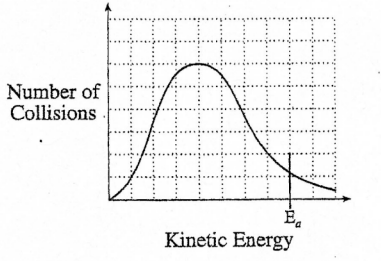


2. When a catalyst is added, the reaction can be represented by a two-step mechanism.

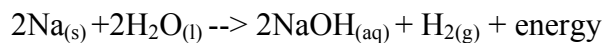
Step 1	$O_3 + NO \rightarrow NO_2 + O_2$
Step 2	$NO_2 + O \rightarrow NO + O_2$

Describe TWO ways that the PE diagram for the catalyzed reaction is different from the PE diagram for the uncatalyzed reaction. (2 marks)

3. Two gases are reacted. Identify two methods to increase the fraction of collisions that are successful. Draw on the diagrams to show the change for each method.

<p>Method 1:</p> <hr/> <hr/> <hr/>	
<p>Method 2:</p> <hr/> <hr/> <hr/>	

4. When solid sodium is placed in water at room temperature, an immediate, violent reaction occurs:



- A) Describe two methods that could be used to experimentally determine the rate of reaction.

Method 1

Method 2

- B) Would you expect the activation energy of this reaction to be high or low? Explain using collision theory. (2 marks)

Appendix G: Student Satisfaction Survey

COMPARING STUDENT ACHIEVEMENT AND SATISFACTION IN TWO CHEMISTRY 12 CLASSROOMS: HYBRID AND TRADITIONAL OFFLINE DELIVERY METHODS – AN IN DEPTH ANALYSIS

Survey of Student Satisfaction with Course Delivery Style

Numeric Identifier: _____

Note: In order to maintain confidentiality, your numerical identifier will not be given to anyone outside of this research study, and will not be revealed to the researchers, until after the course has been completed, and final marks for the course have been submitted.

Instructions

Rate each statement by circling the number that best describes how you feel about the course delivery format you received in your class (i.e., hybrid or traditional offline instruction).

A/ Perceptions of course content

1. The course delivery format that was used in my class made it more difficult to understand the course content than in other science courses I have taken.

Strongly Agree	Agree	Disagree	Strongly Disagree
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2. I believe that the course delivery format that was used in my class was a great way to study the Reaction Kinetics Unit.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

3. The course delivery format that was used in my class provided for an environment that promoted my understanding of the Reaction Kinetics Unit.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

4. Overall, the course delivery format that was used in my class provided me with a successful learning experience.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

5. If provided with the opportunity, I would definitely take another science course delivered in the same format as this course was presented.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

B/ Access to course materials

6. The course delivery format that was used in my class allowed me to easily access class notes.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

7. The course delivery format that was used in my class made it difficult to manage my class materials (such as notes and review questions).

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

8. The course delivery format that was used in my class provided me easy access to course materials, such as review packages.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

9. The course delivery format that was used in this class made it difficult to follow class notes at the pace that I found comfortable for me.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

10. Given the course delivery format that was used in this class, I found it easy to obtain all the classroom materials that I needed for each lesson.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

C/ Communication levels with instructors and peers

11. The course delivery format that was used in my class made it difficult for me to ask my teacher questions about the Reaction Kinetics Unit.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

12. The course delivery format that was used in my class prepared me to participate in classroom discussions.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

13. Given the course delivery format that was used in my class, it was difficult to ask my classmates questions about the Reaction Kinetics Unit.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

14. Given the course delivery format that was used in my class, my teacher promoted group interactions between classmates.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

15. Interacting with the teacher and with other classmates became more natural as the Reaction Kinetics Unit progressed.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

D/ Satisfaction with given grades

16. The course delivery format that was used in my class, did not allow me to achieve the grades that I anticipated at the start of this course.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

17. Given the course delivery format that was used in my class, the grades that I received are reflective of my effort in the Reaction Kinetics Unit.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

18. Given the course delivery format that was used in my class, I am not satisfied with the grades that I received on my assignments.

Strongly Agree	Agree	Disagree	Strongly Disagree
-----------------------	--------------	-----------------	--------------------------

19. Given the course delivery format that was used in my class, I was pleased with the grades that I received on my tests.

Strongly Agree	Agree	Disagree	Strongly Disagree
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20. Given the course delivery format that was used in my class, the overall grades that I received in the Reaction Kinetics Unit are better than what I expected at the start of this Unit.

Strongly Agree	Agree	Disagree	Strongly Disagree
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Appendix H: Invitation to Participate in Research



Department of Curriculum & Pedagogy

Faculty of Education

University of British Columbia

2125 Main Mall

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Vancouver, BC, CANADA, V6T 1Z4

COMPARING STUDENT ACHIEVEMENT AND SATISFACTION IN TWO CHEMISTRY 12 CLASSROOMS: HYBRID AND TRADITIONAL OFFLINE DELIVERY METHODS – AN IN DEPTH ANALYSIS

Principal Investigator: Dr. S. Khan, Faculty of Education, Department of Curriculum and Pedagogy University of British Columbia.

Co-Investigator: Waheeda Mulji, Graduate Student of the Department of Curriculum and Pedagogy, Faculty of Education, University of British Columbia.

Invitation to Participate in the Research Script: (To be read to the class by the volunteer teacher)

I have a consent form for you to take home to your parents regarding a research project that your teacher is conducting. This form explains the study that your teacher is investigating. The goal of the research is to examine how students' achievement levels vary based on the delivery style of the course – for example, either hybrid or traditional offline. Your teacher is also interested in learning more about your satisfaction levels based on the course delivery style – hybrid, or traditional offline, for one unit of study in your Chemistry 12 class.

To investigate this, your teacher will conduct two surveys – the Demographic Survey and the Student Satisfaction Survey. The Demographic Survey is a normal practice of this course, and will ask you questions such as your previous experiences with web-based courses, and

whether you have taken Chemistry 12 previously. This survey will consist of 5 questions, and should take approximately 5 minutes to complete in your classes prior to the start of the Chemistry 12 curriculum. The Student Satisfaction Survey will be given to you at the end of the unit of instruction and will include 20 questions. This survey should take approximately 10 minutes of class time. The Student Satisfaction Survey is also a normal part of the procedures for Chemistry 12. In the survey, students will be able to indicate their personal levels of satisfaction with the course, and the manner in which it was delivered, according to a scale that uses descriptors, such as “strongly agree, agree, disagree, and strongly disagree”.

In order to conduct this research, it is also necessary to collect a pre-assessment, and a post-assessment, both of which are normal activities and practices of this Chemistry 12 course. The pre-assessment will include questions based on a Chemistry 11 Course Review Activity that we will all be completing. The post-assessment is the Unit I Assessment that every student in this class will complete at the end of the unit of study.

You will not be asked to do anything different or unusual in the way that you learn, and all activities that I have just outlined are part of the normal practices and procedures for this course. You will not be required to spend any additional time, in and out of class time to dedicate to this research.

This research will be conducted while we are studying the Reaction Kinetics Unit and, it is estimated to take three weeks, from September 8, 2009 to September 30, 2009.

In order to carry out this research, your teacher is seeking your permission and your parents’ permission, to collect data, in order to address the research questions. Results of this research will be used in a graduate thesis. At no time will your actual identity be disclosed. You will be assigned numerical identifiers to ensure confidentiality. We will maintain the strictest levels of protocols towards any and all information revealed in confidence. Agreement on your part in no way obligates you to remain a part of the study. Participation is voluntary, and you may choose to withdraw from the study at any time.

Please read the consent form that I will distribute now. This form gives you more details about the study and asks you and your parents if it is okay for you to participate. Participating means that you say yes for your teacher to collect data from the two surveys, and the two assessments for the Reaction Kinetics Unit of study. Participating or not participating will not make a difference to the work you do in class, and you will not be treated differently in any way.

You do not have to participate in this study, and should not feel that you have to, to ensure that your standing in this class does not change. If you choose to not consent for this study, you will still complete the two surveys, and write the two assessments, as these are normal practices of this course, however, your data will not be used when analyzing the results for this study. The consent and assent forms will be collected by me. Mrs. Mulji will have no

knowledge of who agreed to participate until after the unit is finished, and final course grades have been assigned.

Please take this form home to your parents and discuss the study with them. The choice is up to you and your parents. If you have questions about this study you may contact your teacher, or the Principal Investigator at the University of British Columbia using the email address or telephone numbers listed on the consent and assent forms.

Forms are due within one week. For instance, today is Tuesday so all forms are due back next Tuesday, by the end of the school day. Please do not give the forms to Mrs. Mulji. It is very important that in order to maintain confidentiality, you return the forms directly to me in my classroom, room 103. I will be collecting both the student assent and parent consent form.

Thank you for your time and patience.

Appendix I: Parent/Guardian Consent Form



Department of Curriculum & Pedagogy

Faculty of Education

University of British Columbia

2125 Main Mall

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Vancouver, BC, CANADA, V6T 1Z4

Parent/Guardian Consent Form

COMPARING STUDENT ACHIEVEMENT AND SATISFACTION IN TWO CHEMISTRY 12 CLASSROOMS: HYBRID AND TRADITIONAL OFFLINE DELIVERY METHODS – AN IN DEPTH ANALYSIS

Principal Investigator: Dr. S. Khan, Faculty of Education, Department of Curriculum and Pedagogy, University of British Columbia.

Co-Investigator: Waheeda Mulji, Graduate Student of the Department of Curriculum and Pedagogy, Faculty of Education, University of British Columbia.

Purpose: The purpose of this study is to compare student satisfaction and student achievement in a traditional offline classroom environment and in a hybrid classroom environment, for one unit of the Chemistry 12 course. The traditional offline course unit will be taught entirely face-to-face, utilizing overhead transparencies and pen and paper notes. The hybrid course unit will be instructed with a mix of online and face-to-face instruction. It is important to note that neither the traditional offline group nor the hybrid group will be disadvantaged in any way as both the traditional offline course unit and the hybrid course unit will share identical course topics and course content. Additionally, the same amount of information will be covered in both classes, and both classes will follow identical lesson plans, identical assignments, and the same lesson notes. The assignment guidelines, marking criteria, and due dates for the assignments will also be identical. The primary differences between the classes will involve the mode of delivery of instruction - either traditional offline or hybrid-based instruction.

The traditional offline course will be taught entirely face-to-face. All instructions will be given verbally and/or will be written on overhead transparencies. Students enrolled in the

hybrid course however, will receive their instruction, online. All information pertinent to the lesson, including course notes and questions, will be found on the course website. Personal computers will be available for each student in the hybrid group, every class in order to accomplish the lesson objectives every day. Labs and group work will remain consistent between both the hybrid and the traditional offline class. All labs will be done in real time utilizing identical lab procedures. Additionally, discussions and group work will occur as part of normal procedures, utilizing identical, face-to-face methods for both groups. The main difference here is the manner in which lesson notes, examples, and discussion questions are accessed by the groups. The hybrid group will utilize the unit website, and the traditional offline group will receive identical information in the form of overhead notes, and/or verbally from the teacher.

Study Procedures: This study will be conducted using methods that include a student pre- and post survey, and a pre- and post-unit assessment. By participating in this study your son/daughter will not be asked to do anything different or unusual in the lesson or in the way that they do their work.

The Demographic Survey is a normal practice of this course, and will ask questions such as previous experiences with web-based courses, and whether students have taken Chemistry 12 previously. The Demographic Survey will consist of 5 questions, and should take approximately 5 minutes to complete during class, prior to the start of the Chemistry 12 curriculum.

The Student Satisfaction Survey will be given at the end of the unit of instruction, and will include 20 questions. This survey should take approximately 10 minutes of class time. The Student Satisfaction Survey is also a normal part of the procedures for Chemistry 12. In the survey, students will be able to indicate their personal levels of satisfaction with the course, and the manner in which it was delivered, according to a scale using descriptors, such as “strongly agree, agree, disagree, and strongly disagree”.

In order to conduct this research, it is also necessary to collect data from a pre-assessment, and a post-assessment, both of which are normal activities and practices of this Chemistry 12 course. The pre-assessment will include questions based on a Chemistry 11 Course Review Activity that all students will be completing. The post-assessment is the Unit I Assessment that every student in this class will complete at the end of the unit of study to measure learning.

Students will not be asked to do anything different or unusual in the way that they learn, and all activities that have been described above are part of the normal practices and procedures for this course. Students will not be required to spend any additional time, in and out of class time to dedicate to this research.

This research will be conducted over a three-week period, from September 8, 2009 to September 30, 2009, and this consent form, is for your son/daughter's participation in one unit of the Chemistry 12 curriculum.

Potential Risks: There are no risks involved in this study.

Potential Benefits: A potential benefit is receiving the final report of this study that will help to improve course delivery methods with respect to student achievement, and student satisfaction.

Confidentiality: Your son/daughter will be invited to participate in this research study at the beginning of his/her Chemistry 12 course. The researcher (Mrs. Mulji), or the Principal Investigator (Dr. S. Khan), will not have access to your son/daughter's consent form until the course has been completed and final marks have been submitted. Thus, marks will not be influenced in any way by whether or not you decide to have your son/daughter take part in this study. The consent forms and all the data collected over the course of the unit will be kept in a locked cabinet to which only the volunteer teacher will have a key. Only code numbers, or pseudonyms will identify all data that is stored. Your son/daughter will NOT be identified by name in any reports of the completed study, unless they so desire.

Contact: If you have any questions or require further information with respect to this study, you may contact Dr. Samia Khan or Waheeda Mulji. Please refer to the top of this form for contact information.

Consent: Please understand that your son/daughter's participation in this research is entirely voluntary and that they may withdraw their contributions at any time, and such withdrawal will not affect their relationship with me, or the school.

Contact for concerns about the rights of research subjects: If you have any questions about your son/daughter's treatment or rights as a research subject you may contact the Director of Research Services at the University of British Columbia, at 604-822-8083, or if long distance, email Martin.Kirk@ors.ubc.ca

Please complete the attached Consent Form to indicate whether you do or do not give your child consent to participate in this study. Please have your child return the consent form to the volunteer teacher in one week. Keep this description of the study for your own reference and detach the slip below.

PARENT CONSENT FORM

Consent for the study: COMPARING STUDENT ACHIEVEMENT AND SATISFACTION
IN TWO CHEMISTRY 12 CLASSROOMS: HYBRID AND TRADITIONAL OFFLINE
DELIVERY METHODS – AN IN DEPTH ANALYSIS

I acknowledge that I have received a copy of this consent form.

Please check the box indicating your decision:

I CONSENT to my child participating in this study as outlined above

I DO NOT CONSENT to my child participating in this study as outlined above

Student Name (Please Print) _____

Parent Signature

Date

Appendix J: Student Assent Form



Department of Curriculum & Pedagogy

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Student Assent Form

COMPARING STUDENT ACHIEVEMENT AND SATISFACTION IN TWO CHEMISTRY 12 CLASSROOMS: HYBRID AND TRADITIONAL OFFLINE DELIVERY METHODS – AN IN DEPTH ANALYSIS

Principal Investigator: Dr. S. Khan, Faculty of Education, Department of curriculum and Pedagogy University of British Columbia.

Co-Investigator: Waheeda Mulji, Graduate Student of the Department of Curriculum and Pedagogy, Faculty of Education, University of British Columbia.

Purpose: The purpose of this study is to compare student satisfaction and student achievement in a traditional offline classroom environment and in a hybrid classroom environment, for one unit of the Chemistry 12 course. The traditional offline course unit will be taught entirely face-to-face, utilizing overhead transparencies and pen and paper notes. The hybrid course unit will be instructed with a mix of online and face-to-face instruction.

Study Procedures: This study will be conducted using methods that include a pre- and post survey, and a pre- and post-unit assessment. By participating in this study you will not be asked to do anything different or unusual in the lesson or in the way that you do your work.

The Demographic Survey is a normal practice of this course, and will ask questions such as previous experiences with web-based courses, and whether you have taken Chemistry 12 previously. The Demographic Survey will consist of 5 questions, and should take

approximately 5 minutes to complete during class, prior to the start of the Chemistry 12 curriculum.

The Student Satisfaction Survey will be given at the end of the unit of instruction, and will include 20 questions. This survey should take approximately 10 minutes of class time. The Student Satisfaction Survey is also a normal part of the procedures for Chemistry 12.

In the survey, students will be able to indicate their personal levels of satisfaction with the course, and the manner in which it was delivered, according to a scale that uses descriptors, such as “strongly agree, agree, disagree, and strongly disagree”.

In order to conduct this research, it is also necessary to collect data from a pre-assessment, and a post-assessment, both of which are normal activities and practices of this Chemistry 12 course. The pre-assessment will include questions based on a Chemistry 11 Course Review Activity that all students will be completing. The post-assessment is the Unit I Assessment that every student in this class will complete at the end of the unit of study to measure learning.

You will not be asked to do anything different or unusual in the way that you learn, and all activities that have been described above are part of the normal practices and procedures for this course. You will not be required to spend any additional time, in and out of class time to dedicate to this research.

This research will be conducted over a three-week period, from September 8, 2009 to September 30, 2009, and this assent form, is for student participation in one unit of the Chemistry 12 curriculum.

Potential Risks: There are no risks involved in this study.

Potential Benefits: A potential benefit is receiving the final report of this study that will help to improve course delivery methods with respect to student achievement, and student satisfaction.

Confidentiality: You will be invited to participate in this research study at the beginning of your Chemistry 12 course. The researcher (Mrs. Mulji), or the Principal Investigator (Dr. S. Khan), will not have access to your assent form until the course has been completed and final marks have been submitted. Thus your marks will not be influenced in any way by whether or not you decide to take part in this study. The assent forms, and all the data collected over the course of the unit, will be kept in a locked cabinet to which only the volunteer teacher will have a key. Only code numbers, or pseudonyms will identify all data that is stored. You will NOT be identified by name in any reports of the completed study, unless you so desire.

Contact: If you have any questions or require further information with respect to this study, you may contact Dr. Samia Khan or Waheeda Mulji. Please refer to the top of this form for contact information.

Contact for concerns about the rights of research subjects: If you have any questions about your treatment or rights as a research subject you may contact the Director of Research Services at the University of British Columbia, at 604-822-8083, or if long distance, email Martin.Kirk@ors.ubc.ca

Assent: Your participation in this study is entirely voluntary and you may refuse to participate or withdraw from the study at any time and any such withdrawal will not affect your relationship with your teacher or the school.

Please sign the attached Assent Form to indicate whether you do or do not consent to participate in this study. Please return the assent form to the volunteer teacher (room 103), in one week. Keep this description of the study for your own reference and detach the slip below.

Waheeda Mulji (Researcher)
Chemistry teacher
MA student in the Faculty of Education, UBC.

Dr. Samia Khan (Principal Investigator)
UBC, Faculty of Education
Department of Curriculum and Pedagogy

STUDENT ASSENT FORM

Assent for the study: COMPARING STUDENT ACHIEVEMENT AND SATISFACTION IN TWO CHEMISTRY 12 CLASSROOMS: HYBRID AND TRADITIONAL OFFLINE DELIVERY METHODS – AN IN DEPTH ANALYSIS

I acknowledge that I have received a copy of this assent form.

Please check the box indicating your decision:

I CONSENT to participating in this study as outlined above

I DO NOT CONSENT to participating in this study as outlined above

Student Name (Please Print) _____

Student Signature

Date

Appendix K: Overview of Literature Review-- Additional Factors

Factor	Author(s), Year	Purpose	Sample	Design
Age and Ability	Young and Duhaney, 2005	Analyze blended learning in undergraduate education	Students under age 35	Case Study
Age and Ability	Riffell and Sibley, 2005	Analyze whether experienced students perform better in online education	Less experienced students "freshmen" and more experienced students "upperclassmen"	Survey
Age and Ability	Barbour and Reeves, 2009	Investigate connections between age and learning outcomes	Students in virtual schools, students from K-12	Case Study
Age and Ability	Leung, 2003	Explore the skills held by 'novice users' of online education tech.	Inexperienced computer/Internet users	Survey
Course Development	Power, 2008	Explore whether there is sufficient course planning information for online classes	Canadian university faculty	Survey
Course Development	Sherry, 1996	Explore whether online/distance learning operates according to a hierarchy of needs	Instructional design personnel, student-instructor-facilitators	Survey
Course Development	Talab and Newhouse, 1993	Attempt to determine which elements are necessary for facilitators to incorporate tech. into the classroom	Student-instructor facilitators	Case Study, further research
Course Development	Burrell-Ihlow, 2009	Clarify roles and responsibilities of college faculty who facilitate hybrid courses	University faculty	Survey
Drawbacks to online ed.	Hoftstein and Lunetta, 2004	Explore hybrid learning in science education	Student users of science laboratories	Case Study

Factor	Author(s), Year	Purpose	Sample	Design
Faculty Course Development	Fillion et al., 2009	Explore perspectives among faculty teaching blended vs. online courses	Canadian university professors using Information and Communication tech (ICT).	Survey
Flexibility	Jonsson, 2005	Increase student interest in medical physics through supplemental hybrid courses	High School students	Case Study
Institutional advantages	Armstrong, 2007	Explore whether online learning offers increased time flexibility	Students in a virtual K-11 school, "The Connections Academy"	Survey
Institutional advantages	Gould, 2003	Explore whether increasing student enrollment makes it difficult for institutions to meet their students' needs	Students and faculty in conventional educational settings	Case Study, survey
Institutional advantages	Hernandez et al., 2007	Investigate whether using open-source software reduces cost while improving accessibility	High school and university users of the open-source e-learning platform ".LRN"	Survey
Learner control	Albrecht, 2006	Investigate whether shifting work from full-time faculty to adjuncts saves money	Faculty at Tallahassee Community College	Case Study
Learner control	Wellburn, 1996	Explore if computer programs that allow students to study at their own pace increases their overall achievement	Students participating in pilot online education programs	Case Study
Learner control	Gunnerson, 2004	Investigate whether increased 'learner control' promote more active learning	Students in programs that provide learner control	Case Study

Factor	Author(s), Year	Purpose	Sample	Design
Learning Styles	El-Gayar and Dennis, 2005	Explore whether hybrid learning allows for innovative materials presentation	Online and hybrid students	Survey
Participation & interaction	Richardson, 2009	Compare online to face-to-face education	Online and traditional offline students	Case Study
Participation & interaction	Shen et al., 2008	Investigate whether increased interactivity in blended classes leads to easier student-teacher interaction	Chinese students	Case Study
Participation & interaction	Lowry et al., 2004	Explore the effects of hybridizing a creative writing class	Creative writing (CW) students	Survey
Student engagement	Beldarrain, 2006	Investigate the consequences of using wikis, blogs, and podcasts in online and distance education	Students enrolled in online and distance education	Survey
Student advantages through online ed.	McCray, 2000	Explore applying online components to business education	College and university students	Case Study
Student advantages	Lago, 2000	Explore whether students in hybrid courses have higher success and lower withdrawal rates	Students at the University of Central Florida	Survey
Student advantages	Leh, 2002	Investigate whether students favor traditional offline or hybrid models of education	Students, though sample was mostly student teachers	Survey
Student advantages	Riviera and Rice, 2002	Explore student performance and satisfaction between traditional offline, hybrid, and online education	Students in traditional offline, hybrid, and online courses	Case Study

Factor	Author(s), Year	Purpose	Sample	Design
Technology Solutions	Gould, 2003	Explore whether students in online courses learn 'soft skills' such as learning how to budget time, think critically, and solve technical problems	Students enrolled in online courses	Case Study
Technology Solutions	Chang et al., 2004	Provide solutions to technical difficulties faced by educators attempting to integrate online education	Teachers in urban and rural schools in Taiwan	Survey
Technology Solutions	McRay, 2000, and Waite, 2007	Present reasons why software advancement will convenience educators in the future	Teachers participating in online education	Case Study
	Barretto et al., 2007	Create evaluative tools for understanding student behavior in online and virtual environments	Students and teachers involved in online education	Case Study

Appendix L: UBC Certificate of Approval – Full Board



The University of British Columbia
Office of Research Services
Behavioural Research Ethics Board
Suite 102, 6190 Agronomy Road, Vancouver, B.C. V6T 1Z3

CERTIFICATE OF APPROVAL - FULL BOARD

PRINCIPAL INVESTIGATOR: Samia Khan	INSTITUTION / DEPARTMENT: UBC/Education/Curriculum and Pedagogy	UBC BREB NUMBER: H09-01788
INSTITUTION(S) WHERE RESEARCH WILL BE CARRIED OUT:		
Institution		Site
UBC		Vancouver (excludes UBC Hospital)
Other locations where the research will be conducted: Enver Creek Secondary School, Surrey B.C. 14505-84 Ave, Surrey, BC, V3S 8X2 Permission to conduct this research has been granted by the Surrey School District. Please refer to section 7.1B, for approval email.		
CO-INVESTIGATOR(S): Samia Khan Waheeda Mulji		
SPONSORING AGENCIES: N/A		
PROJECT TITLE: Comparing Student Achievement and Satisfaction in Two Chemistry 12 Classrooms: Hybrid and Traditional Delivery Methods – An In Depth Analysis		
REB MEETING DATE: August 13, 2009	CERTIFICATE EXPIRY DATE: August 13, 2010	
DOCUMENTS INCLUDED IN THIS APPROVAL:		DATE APPROVED: August 28, 2009
Document Name	Version	Date
Consent Forms:		
Parent/Guardian Consent Form	N/A	August 21, 2009
Assent Forms:		
Student Assent Form	N/A	July 27, 2009
Questionnaire, Questionnaire Cover Letter, Tests:		
Post-Assessment	N/A	July 27, 2009
Post-Course Survey	N/A	July 27, 2009
Primer Activity	N/A	July 27, 2009
Pre-Course Survey	N/A	July 27, 2009
Pre-Assessment	N/A	July 27, 2009
Letter of Initial Contact:		
Invitation to Participate in Research Letter	N/A	July 27, 2009
Other Documents:		
Surrey School District Approval	N/A	July 27, 2009
Other: The website that the hybrid class will use for the unit of study is accessible at: http://members.shaw.ca/chemistry/		

found to be acceptable on ethical grounds for research involving human subjects.

Approval is issued on behalf of the Behavioural Research Ethics Board
and signed electronically by one of the following:

Dr. M. Judith Lynam, Chair
Dr. Ken Craig, Chair
Dr. Jim Rupert, Associate Chair
Dr. Laurie Ford, Associate Chair
Dr. Anita Ho, Associate Chair

Appendix M: Surrey School District Research Approval

SURREY SCHOOL DISTRICT RESEARCH APPROVAL

Please note: The following is an email transcription indicating approval to conduct research

Hello Waheeda,

Please use this email as confirmation of acceptance of your research project in principle entitled "comparing student achievement and satisfaction in two chemistry 12 classrooms". A letter with Sharon Cohen's signature will follow upon her return from vacation, about August 17, 2009.

Regards, Kathryn Peterson

Senior Research Analyst

School District 36 (Surrey)

604-599-7467