

UNIVERSITÉ DE SHERBROOKE

Vidéos contre lectures:

Une évaluation de l'utilisation de vidéos pour accomplir la construction initiale de connaissances

Vodcasts versus readings:

Assessing the effect of using videos to facilitate the initial construction of knowledge

par

Karl R. Laroche

Essai présenté à la Faculté d'éducation

En vue de l'obtention du grade de

Maître en éducation (M.Éd.)

Maîtrise en enseignement au collégial

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a été évalué par un jury composé des personnes suivantes :

Elizabeth Charles

Prénom, initial, nom de famille

Évaluatrice de l'essai

Shernaz Choksi

Prénom, initial, nom de famille

Directrice de l'essai

Essai en maîtrise accepté le

13 Mai 2014

SUMMARY

The goal of this study was to determine whether providing videos for students to watch before class would be more effective than assigning readings. The study took place within a flipped classroom: a methodology designed to engage students in the initial construction of knowledge before class, freeing up classroom time for active learning pedagogies. Preparing for class by watching videos should require less of the students' time than doing readings, and they should respond better to videos than to readings because these more closely mimic this generation's interactions with information and media. Consequently, flipped classroom students provided with videos should perceive a lower workload, which could translate into more positive learning outcomes.

From an instructor's perspective, however, developing and organizing videos is extremely time consuming. Thus, a teacher giving consideration to flipping their class would likely want to know whether videos would lead to positive outcomes for their students before actually committing to developing these. However, no research to date was identified which has examined the question of whether flipped class videos would be more effective than readings.

The hypotheses for the study were that videos would result in measurable learning gains for the students, and would lead to lower time demands and perceived workloads, as well as more positive attitudes. These were tested using a quasi-experimental design involving a convenience sample of two small college General Biology 1 courses taught by the same teacher. One group had videos to watch before class for the first 1/3 of the course (treatment; Class A), during which the other was assigned readings (control; Class B). Following this, both groups were provided with videos. Student scores were compared on pre-instruction and in-class quizzes,

activities, four unit tests, and a final exam. Further, students completed a 44 item survey as well as a demographic questionnaire.

Results suggest greater learning gains for students provided with videos. Certainly, students from Class B improved significantly when provided with videos, especially as compared to Class A, whose improvement over the same time span was marginal. However, conclusions based on these results are somewhat tentative, as Class A performed rather poorly on all summative assessments, and this could have driven the patterns observed, at least partially.

From the surveys, Class B students reported that they spent more time preparing for class, were less likely to do the necessary preparations, and generally perceived their effort and workload levels to be higher. These factors were significant enough that they contributed to four students from Class B (10% of the class) dropping the course over the semester. In addition, students from both groups also reported more positive attitudes towards videos than readings, although they did not necessarily feel that videos were (or would be) a more effective study and learning tool.

The results of this study suggest that any effort on the part of an instructor to prepare or organize videos as pre-class instructional tools would likely be well spent. However, even outside of the context of a flipped classroom, this study provides an indication that assigned readings can place heavy workload requirements on students, which should give cause for any instructor employing mandatory readings to reassess their approach. Finally, since both groups were statistically equivalent across all measured demographic variables, it appears that some of the observed disparities in assessment scores may have been driven by differences in group dynamics. Consequently, the suggestion is made that an instrument to measure classroom climate should be incorporated into any research design comparing two or more

interacting groups of students, as group dynamics have the potential to play a key role in any outcomes.

RÉSUMÉ

L'objectif de cette étude était de déterminer si fournir des vidéos aux étudiants avant une classe serait plus efficace comme méthode d'apprentissage individuel que de leur donner une liste de lectures à compléter. L'étude a eu lieu dans une classe renversée – une stratégie plus reconnue sous le nom de «classroom flipping» – ce qui se trouve à être une méthodologie qui vise à obliger les élèves d'accomplir le transfert de connaissances initial avant la classe, en vue de libérer du temps de classe pour des activités pédagogiques plus approfondies. En théorie, pour les élèves, se préparer pour une classe renversée en regardant des vidéos devrait exiger moins de temps que d'être obligé à apprendre le matériel en lisant. En plus, présenter le matériel d'un cours avec des vidéos imite de plus près les genres d'interactions qu'on les étudiants de cette génération avec de l'information et les médias, ce qui devrait faciliter leur tâche. Par conséquent, les élèves d'une classe renversée fournie avec des vidéos devraient percevoir une charge de travail moins élevée, et ceci pourrait se traduire en bilans d'apprentissage plus positifs.

Cependant, du point de vue du professeur, avoir à développer et organiser des vidéos se présente comme un gros défi, surtout en vue du temps et de l'effort qui sont requis. Ainsi, un enseignant qui songe à renverser sa classe voudrait probablement savoir si le fait d'offrir des vidéos mène à des résultats positifs avant de réellement s'engager dans le développement de ces derniers. Par contre, lors de l'écriture de ce texte, aucune étude n'a été identifiée qui répond à cette question, et aucune publication compare la performance des étudiants lorsqu'ils ont des vidéos à regarder avec lorsqu'ils sont obligés de faire de la lecture pour se préparer.

Alors, les hypothèses de l'étude étaient que des étudiants ayant accès à des vidéos démontreraient des gains d'apprentissages évidents, qu'ils apercevraient des

requêtes de temps moins encombrantes et une charge de travail plus faible, et, en vue de ces derniers, que les étudiants auraient des attitudes plus positives envers le cours et le matériel. Les hypothèses ont été testées à l'aide d'un modèle quasi-expérimental, avec comme échantillon deux classes collégiales de Biologie générale 1, tout les deux enseignés par le même professeur. Un de ces groupes avaient accès à des vidéos pour se préparer pour chaque classe lors du premier tiers du cours, alors que l'autre groupe étaient obligé de faire de la lecture. Après le premier tiers du cours, ce qui fut 10 des 30 classes du semestre, les deux groupes ont été fournis avec des vidéos pour le restant du cours. Des notes ont été ramassées et comparées sur des mini-examens préparatoires avant et durant les classes, sur des activités complétées en classe, sur quatre examens en classe, et un examen final. En outre, les étudiants ont rempli un questionnaire composé de 44 items, ainsi qu'un autre questionnaire démographique.

Les résultats de l'étude suggèrent qu'une décision d'offrir des vidéos aux élèves peut mener à des gains d'apprentissage plus élevés comparativement à l'option lecture. En particulier, les élèves du groupe initial de lecture se sont considérablement améliorées lorsqu'ils ont été fournis avec des vidéos, surtout par rapport au groupe initial de vidéos, dont l'amélioration durant la même période était marginale. Cependant, ces conclusions sont un peu incertaines, parce que la performance du groupe initial de vidéos était globalement médiocre, ce qui aurait pu mener aux résultats observés.

Par contre, les résultats obtenus des questionnaires étaient moins incertains, et indiquent que les élèves qui se sont vues attribués des lectures passaient plus de temps pour préparer leurs classes, étaient plus aptes à ne pas faire les préparatifs nécessaires, et ont aperçus leurs niveaux d'efforts et leurs charges de travaux comme étant plus élevés. Ces facteurs étaient suffisamment importants qu'ils ont contribué au fait que quatre étudiants du groupe de lecture, soit 10% de la classe, ont abandonnés le cours durant le premier tiers du semestre. Finalement, les élèves ont démontrés des attitudes plus positives envers les vidéos, bien qu'ils ne trouvaient pas nécessairement

que ceux-ci étaient plus efficaces que les lectures lorsqu'ils voulaient étudier pour les examens.

Basé sur ces résultats, il est possible de conclure que tout effort de la part d'un instructeur pour préparer ou organiser des vidéos pédagogiques serait probablement un bon investissement. En plus, et même en dehors du contexte d'une classe renversée, cette étude offre une indication qu'une stratégie pédagogique qui oblige les étudiants à faire beaucoup de lecture peut imposer des exigences et une charge de travail très élevée pour les étudiants, ce qui devrait donner cause à tout instructeur qui attribue des lectures à réévaluer leur approche. Enfin, puisque les deux groupes étaient équivalents d'un point de vue statistique sur toutes les mesures démographiques, il semble que certaines disparités entre les deux groupes dans les notes d'évaluation et d'examens peuvent possiblement avoir été entraînées par des différentes dynamiques dans chaque group. Par conséquent, il est suggéré que des mesures de relations entre étudiants et de dynamiques de groupes devraient être incorporé dans n'importe qu'elle recherche comparant deux ou plusieurs groupes d'étudiants, et surtout quand ces étudiants sont en interaction, parce-que en toute apparence les dynamiques de groupes ont le potentiel de jouer un rôle clé dans les résultats obtenus.

DEDICATION

For Buggles and Nuggles, the lights of my life.

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CHAPTER ONE

INTRODUCTION AND STATEMENT OF PURPOSE

A common complaint about introductory college level science education is the amount of content presented in these courses (West, 1966; Lujan & DiCarlo, 2006; Ramsden, 2003), and that faculty make ‘covering’ this content their top priority (Weimer, 2003). However, in many educational systems, and certainly within the Québec CÉGEP system, the basic content for each introductory science course is determined by the government. As a consequence, teachers have no choice but to ‘cover’ a prescribed set of topics, which means that eliminating some of these to dramatically reduce content is not an option for teachers who recognize the often inverse relationship between content and the quality of student learning (Brown, Collins, & Duguid, 1989; Giles, 2009).

This course content quandary is most pronounced in introductory biology classes, which tend to focus on a higher proportion of declarative and conceptual knowledge, and a correspondingly lower amount of procedural problem-solving knowledge, than other science and math courses (Burrowes, 2003; French, Cheesman, Swails, Thomas, & Cheesman, 2007). The result is that introductory biology teachers often find themselves pressed for time towards the end of a semester, racing to finish ‘covering’ all the course content, and occasionally even falling short (personal observation).

Clearly, then, class time in introductory biology, and indeed all science courses, is quite precious. In the past this limitation has typically resulted in such classes following a basic lecture format, where the teacher takes responsibility for the initial transfer of all of the content information. In this format, the teacher can set the

pace of the course, and can comfortably ‘cover’ all the required content. However, since this type of teaching has repeatedly been shown to result in surface approaches to learning and poorer learning outcomes (Anderson & Krathwohl, 2001; Ramsden, 2003), a more effective method of teaching might be one which requires students to take responsibility for the initial transfer of knowledge by encouraging them to do readings and activities before class. Adopting this approach would make the students themselves ‘cover’ the content, which could then theoretically free up class time for teachers to employ more constructivist pedagogies based on student centered active learning (Bean, 1996; Richardson, 2003; Slavin, 1994), with the goal of helping the students solidify an understanding of the knowledge they’ve incorporated (Anderson & Krathwohl, 2001; Ramsden, 2003).

This would certainly be possible for a course like introductory biology, because all the content information the students require is laid out very clearly in the biology text that accompanies the course. In fact, a majority of students likely use the text as one of their primary sources of information when studying for assessments (Boud & Falchikov, 2007; Stiggins, 2003). Thus, by identifying for the students exactly what sections of the text they need to read and what they should be able to do after completing the readings (listing the learning outcomes), it is possible to mandate that the students learn all the content for themselves before class, and thus come to class prepared for activities.

One major caveat with this particular approach, however, is the substantial workload demands it places on students. An average introductory biology text chapter takes approximately two hours to read once, and more than one reading is required to develop a solid understanding of the material (estimation made based on personal experience as a biology student); this approximation does not consider the difficulties that many college level students have with reading comprehension (Dole, Duffy, Roehler, & Pearson, 1991), which could dramatically increase reading times (or decrease them, if students read the text quickly but do not internalize any of it).

Considering that introductory biology courses often proceed at a pace of about one chapter per class (personal observation based on a 75 minute class period), adopting an approach where students are required to do readings before class would force them to do at least four hours of reading per week just to keep up with in-class activities; a time demand that would come in addition to those of any activities, assignments, projects, and general studying. Consequently, the heavy workload demands this pedagogical approach places on students may unwittingly force them into surface learning styles, while attempting to do just the opposite.

One way to address this problem is through “classroom flipping” using “vodcasting”. Classroom flipping technically refers to the basic pedagogical strategy described above, which is to get students to engage in the initial transfer of knowledge outside of class, and to use classroom time for teacher assisted homework style activities and group work (National Science Teachers Association, 2012). In this way the class is “flipped”, with traditional lecture roles being undertaken at home, and traditional homework activities being done in the class. However, the term classroom flipping has, for the most part, come to be directly associated with the practice of ‘vodcasting’, which is to create videos of lecture or course material and distribute them in a way that allows students to watch them outside of class (Brunsell & Horejsi, 2011; Kay, 2012). It’s important to note, though, that vodcasting does not directly imply flipping, as videos can be, and in fact typically have been, provided simply as supplemental or review materials, with class-time still following a mostly traditional lecture format (Walker, Cotner, & Beerman, 2011).

The practice of vodcasting for flipped classes provides a potentially elegant solution to the workload problem described above. For one, the course content included in one introductory biology text chapter, which would take students approximately two hours to read once, can be vodcasted to them in a handful of short and well planned out videos for a total viewing time of about 25 minutes, thus dramatically reducing the time students require to prepare for each class and,

consequently, the overall workload. Further, videos also side-step any potential difficulties students might have with reading comprehension (albeit not requiring them to improve their reading comprehension skills).

Based on these advantages, as well as on elements of educational and psychological theory (further explored in Chapter Two), it would seem reasonable to hypothesize that videos should be more effective than pre-class readings when employing a flipped class approach. However, there is currently no empirical evidence to support this hypothesis, even though providing such evidence could have important implications. Most importantly, because developing and preparing interesting videos imposes significant time demands on teachers, such results might encourage hesitant teachers to commit to putting in the effort necessary to modify their pedagogical approach. Similarly, current vodcasters would benefit from an empirical validation of the effort they have already put in.

Ultimately, online video's novelty, versatility, and accessibility have the potential to increase student engagement in the classroom by freeing up time for constructivist-style pedagogical approaches like discussions and activities. There is a great deal of evidence in the literature that active pedagogies results in significant gains in student learning (Prince, 2004); now it simply remains to be determined whether using videos to free up class time for such approaches is worth the effort, or whether providing students with a simple list of readings is equally as effective.

CHAPTER TWO

CONCEPTUAL FRAMEWORK

1. ACTIVE LEARNING

There are numerous elements underpinning the conceptual framework of this project. First and foremost, the entire approach is based on active learning principles, which are rooted in constructivist theory (Brown *et al.*, 1989). Drawing on the seminal works of cognitive psychologists like Piaget, Vygotsky, and Bruner, constructivism is the idea that learners need to individually discover, develop, and ultimately transform complex information into their own constructed understanding if they are to truly make it their own (Driscoll, 2000; Ramsden, 1992; Slavin, 1994). In education, and particularly in a classroom setting, constructivism takes practical form as instructional strategies which lead students to actively engage with and apply the material they are learning, rather than to passively absorb information through lectures (Mayer, 1992; Myers & Jones, 1993; Richardson, 2003; Smith & Ragan, 1999). This form of active learning is particularly effective when understanding is constructed socially, typically based on working in small groups (Bean, 1996). Correspondingly, the goal of this project is to successfully free up class time for students to engage in group work activities. Regardless of the method employed to ensure students come to class prepared for these activities, the fundamental learning principles at play are that students should be actively engaged in the classroom, rather than passively receptive.

2. CLASSROOM FLIPPING

With constructivism and active learning as a foundation, the true focus of this project is on determining the most effective method for getting students to

engage in the initial transfer of knowledge before class, so that active pedagogies can be adopted within the classroom. This approach to teaching is called ‘classroom flipping’ (Brunsell & Horejsi, 2011; National Science Teachers Association, 2012). As alluded to in Chapter One, educational and psychological theory support the hypothesis that providing students with videos to watch before class should be a more effective method of flipping classes than having them read chapters from a text. There are several areas of research which provide support for this hypothesis; these will be examined in the following sections.

2.1 Information Processing Models of the Mind

Information-processing models of the mind hold that there are three main memory registers: sensory memory, short-term or working memory, and long-term memory (Atkinson & Shiffrin, 1968). Short-term memory is limited in capacity and duration, which means it can become overloaded during learning activities, resulting in diminished learning outcomes (Mayer, Bove, Bryman, Mars, & Tapangco, 1996; Sweller, 1988). However, short-term memory is also commonly thought to contain separate processing systems for verbal/auditory information and for visual/imagery information (Mayer & Moreno, 1998), which implies that it should be possible to reduce cognitive load and improve learning outcomes through the dual coding of information. In other words, stimulating both visual and verbal channels of working memory should increase the amount of memory that is effectively available, enhancing the encoding of information into long-term memory and its ability to be retrieved (Clark & Paivio, 1991).

This theory supports the idea that videos, with stimulating images, animated text, and catchy voice-overs, should be an effective way to maximize student working memory for the initial transfer of knowledge. Of course, text books also provide a combination of verbal and visual information, in the form of text and graphics/images. However, while both approaches employ dual coding of

information, research evidence contends that video provides greater stimulation for the senses, and is often more targeted than text, which helps to ground and contextualise abstract concepts for memory encoding (Kuzma & Haney, 2001; Lonn & Teasley, 2009; Zhu & Grabowski, 2006). Thus, strictly from a working memory perspective, theory supports the hypothesis that videos should be a more effective method of information delivery than text.

2.2 Motivational Theory for Digital Natives

Another line of support for the hypothesis comes from motivational theory, in particular as it relates to the current generation of students. Prensky (2001) argues that students today are digital natives with different learning patterns and, perhaps, different methods for processing information. The suggestion made is that a digital native student might learn better in a ‘video game’ situation rather than in a typical lecture situation with required readings. The theory of dual encoding presented above explains a portion of this, but another important element relates to student motivation. A substantial body of literature maintains that students display the highest and most persistent levels of cognitive engagement with academic tasks that they find interesting, pertinent, and relatable, because it is these tasks that inspire in them the greatest levels of intrinsic motivation and commitment (Beghetto, 2004; Moore, 1994; Pintrich & Schrauben, 1992). Given that the current generation of students have matured in the internet age, with consistent exposure to a wide variety of on-demand multimedia sources of information and sensory stimulation, they are more likely to feel comfortable with and relate to internet accessible on-demand videos as a source of academic information than they are to long sections of text, because videos more closely approximate the reality of their non-academic interactions with information and technology (Dahlstrom, de Boor, Grunwald, & Vockley, 2011; Oblinger & Oblinger, 2005; Prensky, 2001). This familiarity, then, is more likely to result in higher levels of motivation, which, in turn, should translate into greater cognitive engagement.

2.3 Perceptions of Workload

Familiarity and motivation are also key factors in student perception of workload, and this provides yet another important piece of theory to support the hypothesis guiding this project. A great deal of research suggests that, while workload is a significant determinant of the learning approach adopted by individual students, their perception of workload requirements are actually influenced by a complex interaction of factors, of which actual time studying forms only a part (Giles, 2009; Kember, 2004; Kember & Leung, 2006; Lizzio, Wilson, & Simons, 2002). Consequently, it is possible to require relatively high overall time commitments from students while still maintaining their perceptions of a fair and balanced workload, by employing strategies and tactics which promote familiarity and intrinsic motivation, and which therefore keep the students interested and willing to engage in the tasks at hand.

To be sure, with the strategy being explored here, a large portion of the responsibility for achieving this level of interest will come from the in-class active learning pedagogies, which have the greatest potential to inspire students through social constructivist interactions. However, the bulk of student perceived workload will stem from pre- or post- class assignments (students are already committed to class time, but “out of class” assignments detract from the students’ own free time, making them seem like more work), meaning the emphasis is on developing these in a way that maintains student perceptions of fair and reasonable teacher expectations. Given the time constraints associated with watching videos as compared to reading chapters from a text (outlined in Chapter One), and in light of the greater probability that students will relate to and appreciate videos as compared to readings, theory clearly suggests that students are more likely to perceive the workload stemming from video assignments as lighter and more manageable than the workload imposed by reading assignments. As a consequence, students should be more likely to engage in deeper learning strategies in flipped classes with video assignments than those with

readings, and this should, ultimately, lead to measurable differences in student learning outcomes.

2.4 Connectivism

All of the theory outlined to this point is essentially summed up by a theory called Connectivism (Siemens, 2004), which makes accommodation for the new ways people connect and learn in the digital age. The suggestion made is that, in the last two decades, technology has restructured how we live, communicate, and learn, and that forming connections and sharing the experiences of others has become one of the most crucial methods of developing our own experience and competence. As a result, Siemens (2004) argues against lecture and traditional isolated methods of education, stating that free and open technology resources now enable educators to record, broadcast, and archive basic course content in ways that was not possible only a decade ago. Instead the author provides a strong argument in favour of a restructuring of education towards more student-centered pedagogy, with class time devoted to one on one and group interactions. In essence, Siemens (2004) provides one of the first and yet most comprehensive theoretical arguments in favour of classroom flipping by means of vodcasting.

CHAPTER THREE

LITERATURE REVIEW

The videos discussed in Chapters One and Two refer to what are now being called ‘vodcasts’ (Kay, 2012). This term combines the words ‘video’ and ‘podcast’, where a podcast is any file distributed in a digital format through the internet using personal computers or mobile devices. Vodcasting, in all of its forms, is a fairly new pedagogical strategy, first appearing in approximately 2007, although only truly gaining in popularity in the past two or three years (Kay, 2012; National Science Teachers Association, 2012). The major factors contributing to the inception, development, and growth of vodcasting as a pedagogical strategy were the launch of YouTube in 2005, and the steady increase in student and teacher access to internet bandwidth from 2005 onward (Kay, 2012). With these elements in place, and with the development of easy screen-capture software like Camtasia and Adobe Captivate, it became fairly straightforward for teachers to create and post videos for student use.

As a result, several research studies have been conducted in the past several years to examine different facets of vodcasting, employing quantitative, qualitative, or a combination of both approaches. However, a review of the literature uncovered very few studies pertaining to the use of videos for classroom flipping, none of which actually directly address this pedagogical approach. Further, no research was identified which directly compares the use of videos versus assigned readings. Instead, background information on the utility of videos comes predominantly from studies of North American or British Math and Science undergraduate courses (although a non-negligible number of studies were conducted in Arts and Business courses as well) where vodcasts were used either as supplementary material or as substitutes for missed classes, but where the teacher maintained a predominantly

lecture-style approach. Despite this, these studies provide a wealth of information pertinent here, especially pertaining to student perceptions of and interactions with vodcasts, the overall benefits and challenges of employing videos, and, ultimately, of how videos need to fit within well conceived pedagogical plans.

In the following pages, a selection of these studies will be reviewed to provide a further theoretical and methodological underpinning for the research proposed here. All the studies considered are fundamentally similar, in that they appear to have been conducted by educators who are reporting on their initial use of this new vodcasting methodology. Consequently, most of the research questions examined within these papers are variations on the same theme. However there are important differences, and these will be highlighted as each study is described. The review will first focus on studies that did not incorporate direct measures of student learning through assessment scores, will then examine several studies that did do this, and will conclude by elaborating on the few studies uncovered that at least peripherally considered using videos within a flipped class methodology.

1. STUDIES WITHOUT ASSESSMENT SCORES

The studies that did not incorporate a direct measure of student learning focused primarily on student perceptions of vodcasts and on how students actually engaged with and used these resources. In all cases the overall goal was to assess whether students felt that the use of vodcasts was valuable and worthwhile, and whether their actual use of the resources was in line with their reported sentiments.

The first study examined here is Kay and Kletskin (2012). Here, a first year university undergraduate Calculus class consisting of 288 students was provided with 59 short (mean length of 7:40) problem-based vodcasts. It's important to note, though, that the vodcasts were supplementary material only made available during the first three weeks of the course (before a diagnostic test), and that the content

consisted of pre-calculus problems, meant to help the students build and solidify their mathematical foundation. Thus, the vodcasts were not mandatory viewing, and the course still adopted a general lecture-based methodology. All of the videos were loaded onto a customized website with a tracking tool designed by the authors, which could not only log student access to the videos but also track how these were being used.

Data for this study were collected using the aforementioned tracking tool, as well as through a student questionnaire. On this survey document, students were asked demographic questions, closed and open-ended questions on why they did or did not view the videos and, if they did, of their overall impressions, and finally of whether they felt that their pre-calculus knowledge improved as a result of having used the vodcasts.

The videos were only made available for 3 weeks, and the authors reported an impressive mean of 223 visits to the website per day ($sd = 151$), even though only 195 students actually made use of the vodcasts. The study indicated that use of the videos was greatest outside of school on the student's own time, predominantly in the evening. In particular, though, it was noted that use was considerably greater across all measures (total visits, mean views per day, total viewing time) during the four days before the diagnostic test. These results suggest that students tend to use vodcasts as a "just-in-time resource" before being assessed (p. 624). These usage results represent one of the main strengths of this study, because they combined both student-reported usage data with actual tracking data, to develop a more complete picture that isn't provided in most other studies.

With regard to student perceptions, a large majority of students who watched the vodcasts (87%) rated them as useful, citing several generalized learning benefits, such as increases in motivation, improvements in the ability to recall and recognize, and the clarification of key concepts and procedures. Further, students identified

convenience as being very important, citing how they enjoyed being able to select the time and place to watch, and also mentioned that the ability to control the pace of their own learning was a major benefit. Further, a small number of students indicated that having the vodcasts available helped reduce anxiety associated with a testing situation. Of those students who didn't use the videos, the main reasons cited were that they didn't think they needed to, didn't know they were there, or didn't have the time.

Finally, a paired t-test revealed significant gains in five pre-calculus learning categories, and the authors indicated significant positive correlations between student-reported vodcast use and their self-assessed change in understanding, all with r values in the range of 0.2 – 0.25. However, it's important to note that, while these results may seem noteworthy, they are somewhat suspect. For one, because the authors don't clearly identify the type of data they collected to measure the learning gains (these were likely ordinal or interval scale), the use of parametric tests may not have been appropriate, and may have produced false positives. Further, the r values reported as statistically significant correlations are actually fairly weak. Despite these potential statistical issues, however, the fact remains that the quantitative results are in line with the qualitative results obtained from student feedback. The main drawback with the numbers, of course, is that they are all student-reported, as opposed to direct measures of student achievements. The authors do fully acknowledge these shortcomings in their study, though, and are careful not to over-reach with regard to the conclusions they draw. Ultimately, then, this study provides a fairly thorough and detailed examination of student video use and of their perceptions of the resources overall.

This study was presented first, and in a fair amount of detail, because the results obtained with regard to usage and student perceptions are remarkably similar across all studies included in this review. Broadly speaking, students appear to enjoy and appreciate vodcasts when provided with the resource, and tend to watch them on

their own time, outside of school, and predominantly on their own computers (as opposed to on mobile devices). Further, in all studies examined a majority of students used the videos, but, for those that didn't the reasons were always similar to those reported above, as opposed to for theoretical or ideological reasons. Thus, because these results are so ubiquitous, they will not be addressed again unless a particular study identifies something significantly different.

Another study which focuses exclusively on student perceptions of vodcasts is Chester, Buntine, Hammond, and Atkinson (2011). Here, the authors' intentions were to essentially gather student feedback regarding newly installed lecture recording and distribution software at an Australian university. They eventually decided to sample from six different courses incorporating a wide range of disciplines, and provided each of these classes with two questionnaires over the course of the semester. The first of these questionnaires asked both Likert scale and open-ended questions relating to student use of and overall usefulness of the recordings; interestingly, though, the questionnaires also incorporated questions meant to assess students using the Academic Behaviour Confidence scale (Sander and Sanders, 2006, as cited in Chester *et al.*, 2011). The second questionnaire, provided at the end of the semester, focused exclusively on use of the vodcasts for examination revision.

Response rate to the questionnaires was not particularly impressive, with only a 43% return rate (288 in total) for the first questionnaire and a 12% return rate (88 in total) for the second. Thus, the results from this study need to be viewed with a degree of caution, because the low response rate suggests that the student sample collected may not have been very representative of any broader population.

Results indicated fairly low usage of the lecture recordings during the semester (42%), but that usage increased significantly before exams (70%). Many of the other findings were also similar to those described for Kay and Kletskin (2012)

above. This study is included here, though, because it does contribute some novel insights. First, there was a large variation in video usage across courses (e.g., <25% in an introductory Psychology class and 100% in a Social Work class), suggesting that not all groups of students approach their academic learning in the same way. Also, age, employment, and absenteeism all correlated positively with time spent viewing (no statistics are provided to support this claim), suggesting potentially that students with greater responsibilities used the convenience of being able to watch lecture videos at their leisure in order to avoid the fixed time commitments of class lectures. Finally, academic self-efficacy also correlated positively with video watching, although this also correlated with age, which obscures the potential utility of this finding. Ultimately, then, Chester *et al.* (2011) suggests that student interest and maturity, as well as their extracurricular responsibilities, can all be important factors in how they perceive of and interact with video resources.

Evans (2008) also exclusively used questionnaires to address their hypotheses, but is one of only two papers uncovered in this review which asked students to compare videos and readings. In this study, students from a first year undergraduate Business and Management course at a university in London, England were provided with three online vodcasts during the three week “revision” period between the end of class and the exam period. Thus, these vodcasts consisted exclusively of revision material, and the regular semester classes proceeded using a traditional lecture format. Students were allowed to access the first two vodcasts, but needed to complete a survey consisting of 15 Likert scale questions, two open-ended questions, and six demographic questions in order to gain access to the third. Overall, 196 students completed the survey out of a class of 400.

The results of the survey suggested that a majority of students thought that revising from vodcasts was quicker than revising from notes, but not necessarily more effective. In contrast, most students felt that revising using the vodcasts was both quicker and more effective than using textbooks. Finally, significantly more

students believed that they were more receptive to material delivered using vodcasts than to either textbooks or traditional revision lectures.

The findings of this study are not particularly useful for drawing broad conclusions. For one, the authors did not implement any form of quasi-experimental design, choosing instead to simply survey one group of students. Also, by not including any direct measure of student learning achievements, conclusions are limited exclusively to student perceptions and opinions. Finally, the fact that less than 50% of the class actually completed the survey to obtain the final videos casts doubt on any results suggesting that students view these as more effective. Still, despite these shortcomings, this study does provide theoretical support for the basic guiding hypothesis behind the present research comparing the effectiveness of pre-class videos versus readings within a flipped class setting.

In contrast to the results in Evans (2008), however, Mann, Wong, and Park (2009) actually obtained results suggesting students prefer printed materials and lectures instead of videos. In this study, two cohorts of first year undergraduate Science students in a Physics class at a university in the UK were provided with lecture videos to accompany traditional reading materials and lectures. Their impressions of the various methods were collected using very basic questionnaires: students were simply asked to provide a rating out of 5 for each of a) printed materials, b) lectures, c) videos, and to provide an explanation for each. Any potential ambiguities were subsequently cleared up using semi-structured interviews. In all, 65 questionnaires were returned out of 187 potential respondents.

As alluded to above, the results of these questionnaires indicated higher ratings for both printed materials and lectures than for the videos provided. On the surface, this would seem to provide evidence against the rationale underlying the present research. However, these results must, at the minimum, be considered cautiously. For one, the authors provide very few details about the vodcasts they

produced, leaving it within the realm of possibilities that the quality of these resources simply wasn't up to those of the printed materials or of the well rehearsed lectures. In addition, from a methodological and statistical perspective, a response rate of only about 35% casts doubt on both the external and internal validity of the study. Further, the study set-up appears to have been somewhat haphazard, and, at the very least, the method of data collection seems to have been far from systematic. Finally, the authors don't actually conduct any form of numerical analysis other than to present summarized results, which makes it impossible to gauge the statistical validity of their findings. Thus, while the results of this study do cast a degree of doubt on the theory underlying the present research, these cannot be weighted heavily against the preponderance of empirical support provided to this point.

2. STUDIES THAT INCORPORATE ASSESSMENT SCORES

Many published studies took their research a step further than what has been presented so far, by incorporating at least some direct measure of student achievement, rather than simply asking students to self-assess their own learning gains. Others went even further still, by establishing quasi-experimental designs which made it possible to compare assessment scores from control and experimental groups. All of these studies also incorporated both qualitative and quantitative measures of student perspectives, typically in the form of questionnaires and semi-structured interviews. However, since the results obtained through these measures all essentially mirror what has already been presented, this section of the literature review will focus primarily on findings stemming from direct summative assessments, and the comparison of these between different groups.

Hill and Nelson (2011) is a study that used indirect methods to assess student learning gains. In this study, a single university class on exotic ecosystems, consisting of 33 students, was provided with 6 separate vodcasts over the course of the semester, created to display a visual representation of environments and processes discussed in

lectures and seminars. To assess the effectiveness of these videos, the authors administered a written questionnaire and conducted focus groups; however, they also compared scores on two summative midterm tests and a cumulative final exam with those from a class conducted two years previous to determine whether the introduction of vodcasts would have an effect on student scores.

The results of the questionnaires and focus groups echoed those presented in the section above, but, despite the overall positive response from students, summative scores did not significantly improve as compared with those from the previous group. Of course, the limitations of these results are clear: despite best efforts at keeping class content and approach the same across several years, the authors weren't able to provide any assurances that the two cohorts were essentially equivalent from the start. In other words, the authors weren't able to discount the possibility that their vodcast group was generally weaker but was brought up to the level of the previous group with the assistance of the vodcasts. Regardless, the authors concluded by identifying that students perceived the primary strength of the vodcasts to be in helping them remember facts, as opposed to facilitating a deeper understanding of processes, and that there is therefore a need to anchor the flexibility of the technology within more engaging activities that are scaffolded (supported) and anchored (made purposeful) by the instructor.

Unlike Hill and Nelson (2011), most other studies actually did identify significant improvements in student scores as a result of vodcast use. In Vajocski, Watt, Marquis, and Holshausen (2010), an ex post facto research design was employed to assess the effectiveness of vodcasts as a learning tool across a large multi-sectioned first year university course and two large single section upper year courses. The only other explicit details the authors provide about the methodology are that Social Science courses were included in the study, and that at least one Economics class (or section) was provided with vodcasts and was thus an experimental group, while at least another economics class (or section) did not have

access to these resources, and was therefore the post-hoc control. The authors provided a mark incentive for students to participate in an online survey, and received a high (>80%) participation rate from a total student group of 1675. Final letter grades were also compared between the experimental and control Economics sections to determine whether students provided with vodcasts performed better than those that did not have access to the videos.

Their results seemed to indicate a clear effect of vodcasts on student achievement in the Economics course: there were higher numbers of As and Bs in the experimental group than the control (Bs were significantly different with $p = 0.01$), while Cs and Fs were significantly higher in the control group ($p < 0.001$ and $p = 0.03$, respectively). However, as for Hill and Nelson (2011), these results must be viewed with a substantial degree of skepticism. Here, the issue stems predominantly from the authors providing an abysmally paltry amount of methodological details, which makes it impossible to determine the internal and external validity of the results. Further, the authors analyzed their grade results using t-tests, but it's not even entirely clear that they had multiple experimental and control groups from which to calculate means in the first place. Thus, while this study does apparently provide quasi-experimental evidence supporting the use of vodcasts, on its own it would not carry much theoretical weight.

Fortunately, several other studies assessing the effectiveness of vodcasts were very well conducted, and do bolster this theoretical support. First among these is Traphagan, Kusera, and Kishi (2010), which used a quasi-experimental design to compare two course sections from a large enrollment geology course at Southwestern university. In this study, one section of students (153) could access simple lecture vodcasts online (i.e., the class remained lecture-based, and vodcasts were recordings of the lectures), while the other group (211) could not; otherwise, everything between the two classes was practically identical.

Other than the standard goals regarding gauging student perceptions of the approach, the authors particularly wanted to examine the effect of vodcasts on student attendance in class, and to then correlate these results with student performance, in this case to determine whether lecture vodcasts had a negative effect on student scores. To that effect, data were collected by means of the usual questionnaires and assessment scores, but also by taking attendance in class and by means of an online tracking system which could log when students accessed the videos. Finally, the authors collected information about student GPA before the course as a pre-emptive comparative measure between the two groups, and discovered that the control section had a significantly higher mean GPA. Consequently, GPA was used as a covariate in their subsequent analysis: they conducted a one-way ANCOVA analysis with attendance as the dependent variable, section as the independent variable, and GPA as the covariate; and a one-way MANCOVA analysis to test performance differences between sections, controlling for GPA and absence.

Interestingly, although not necessarily surprisingly, attendance in the vodcast section was, on average, 9% lower than in the no vodcast section; a difference which was significant at $p < 0.01$ when controlling for GPA. There was also a moderate positive correlation ($r = .4$) between the number of videos watched and the number of missed classes. Based on these results, the authors ran a multiple regression modeling GPA, gender, reason for taking the course, other online resources, and vodcast viewing frequency, and this suggested that vodcasts and other online resources ultimately had a negative impact on attendance. Seemingly in line with this finding, the control section produced average scores on the summative assessments that were significantly higher than those in the experimental section; however, controlling for initial GPA ultimately revealed that performance on the tests was not statistically different between the two groups. Consequently, it appears that absenteeism may not have been correlated with a decrease in scores.

To further examine the relationship between absenteeism, vodcast viewing, and test scores, the authors conducted a path analysis using the vodcast section data. This analysis suggests that vodcast viewing actually had a positive and significant effect on performance measures, i.e., the students that watched more scored better on the tests. It also identifies a significant negative effect of absenteeism on assessment scores. What these results ultimately imply is that, in this study, vodcasting mitigated the negative effects of absenteeism on overall scores, meaning that it was possible for students to skip class and still do well as long as they watched the videos.

Ultimately, Traphagan *et al.* (2010) is a well conducted and well analyzed study which provides support for the use of vodcasts. While their study suggests that students might skip class as a result of vodcast use, it's important to note that the classes were lecture-based, and that the videos were simple recordings of these. Consequently, students who skipped could actually watch the entire lecture anyways, almost as though they had actually attended class. In a flipped class setting, classroom time would be devoted to activities rather than lecturing, meaning that the link uncovered here between videos and skipping would no longer be relevant. As a consequence, the authors suggest that their results could be used as an incentive to develop flipped-style pedagogy, and that traditional lecturing might not be best model of post-secondary education.

Another well orchestrated study is described in Walker, Cotner, and Beerman (2011). This study used a setup very similar to the one in Traphagan *et al.* (2010), but here to test the potential difference between instructor-produced vodcasts on class material and simple lecture video captures. In other words, the authors planned on providing students with vodcasts regardless, but wanted to determine whether it was worthwhile for instructors to spend time creating content-targeted vodcasts for the students to view, or whether it was sufficient to simply provide videos of class lectures.

Here, two first year Biology courses focusing on evolution were used as the sample. One group was provided with animated vodcasts on evolutionary material, while the other group only had access to lecture-videos. Otherwise, everything remained constant between the two groups. Demographic characteristics were collected for each group, including GPA, but identified no significant differences between the two groups. Data for this experiment were collected based on questionnaires, assessment grades, and scores on particular evolution questions.

The authors ran a multivariate regression modeling basic demographic characteristics, GPA, section, and test scores, and this indicated that the vodcast group scored significantly higher on the evolution questions ($p < 0.01$). However, overall score between the two groups was not statistically different. These results might initially dampen enthusiasm for instructor-produced vodcasts, but it's important to note that the vodcasts specifically targeted evolutionary concepts. Since a difference was observed in questions pertaining to this material, it's possible that the remaining material in the course may have resulted in background noise which swamped out the positive pedagogical effects of the instructor-produced videos. The authors describe this possibility, and, like many of the studies presented to this point, go on to suggest that the impact of instructor-produced vodcasts could be compounded if they are used to convey the basic material outside of class, using class-time instead for more activity-based learning. With that in mind, the following section will describe those studies uncovered in this review which even considered this possibility, to see whether videos are well-suited for a flipped class setting.

3. VIDEOS IN FLIPPED CLASSES

A great deal of evidence supports the idea that active learning classrooms result in student learning gains (see Prince, 2004, for a review). As a result, our project will be based around a flipped class methodology, where classroom time will consist almost exclusively of small group activities, and the research will focus on the effectiveness of using videos as a method of having students prepare for these activities before class. Two research studies were identified which gave consideration to this pedagogical approach, albeit only peripherally. Still, they do provide even further theoretical evidence in favour of the basic rationale underlying our project.

The first of these studies is O'Bannon, Lubke, Beard, and Britt (2011), which was conducted using four sections from a fourth year Educational Technology course at a large Southeastern university. Using a quasi-experimental design, two of these sections were set up as the treatment groups and provided access to lecture-mimicking vodcasts, while the other two sections were controls that did not have access to these resources. Otherwise, everything – except the teacher – remained constant across all four sections. For each, the basic course procedure was for the students to do readings, then either watch a vodcast or attend lecture (depending on whether they were in the treatment or control; no group did both), followed by watching demonstrations, participating in practice activities, and finally developing their own materials. Consequently, the research question here was actually asking whether providing vodcasts instead of lectures would be detrimental to student learning gains; in other words, whether giving them videos instead of lectures would result in a decrease in scores.

It is not immediately clear from the paper whether students in the experimental group actually had extra activity time in class, or whether the hours that would have been spent in class were instead simply spent watching videos. If there was no extra activity time, then this approach wouldn't really count as classroom

flipping, because there would not have been any actual change in class procedures. Regardless, this study can still provide important information about flipping, because the general course approach the authors describe involved a great deal of active learning; in this case, then, the results of interest relate to the effectiveness of videos as a precursor for classroom activities.

Similar to the experimental studies already presented, data in O'Bannon *et al.* (2011) were collected based on both surveys and chapter quiz scores. At first glance, it would appear that the vodcast sections performed better on the chapter quizzes than the control groups: with means of 89.23 and 85.72, respectively, a t-test comparing mean scores from the two groups produced a p-value of 0.004. However, the authors proceed to state that this “indicat(es) that there is no significant difference in achievement of the two groups at .05” (p. 1889). This interpretation is perplexing, to say the least. Other than a gross misinterpretation, the only possible explanation for it is that the t-test was a one-tailed, testing the hypothesis that videos had a negative effect on scores; since this was not the case, the proper interpretation would be to accept the null. However, the authors never clarify this point, making it difficult for the reader to draw appropriate conclusions.

Regardless, it is clear that vodcasts did not hinder student abilities to prepare properly for class and for tests, and may in fact have been beneficial. Thus, the study appears to provide at least some support for the hypothesis that videos would be an effective mechanism to help students prepare for the activities in a flipped class.

The final study being considered in this review also provided similar support for using videos to flip classes. Day and Foley (2006) is an extremely meticulously run study which comes the closest to actually testing out a flipped class methodology. Here, a quasi-experimental design was used in a Computer course for senior undergraduates at a Southeastern university. One section of the course with 28 students had most of their in-class lectures replaced with short web-lectures

(vodcasts), while 18 students from a control section had regular lectures. Both groups had the same pre-class homework assignments. Interestingly, the authors wanted to ensure that any differences they observed would stem from the methodology itself rather than from extra mandated course time, and so they limited the amount of class activity time for the treatment section such that expected video watching time plus the class activity time would equal the overall allotted lecture time for the control section. Thus, both groups had equal time expectations placed upon them, and the treatment group really only represented a partially flipped class.

Despite this reduction in class activity, though, the treatment group scored better on every assessment (homework, project, exams) throughout the semester, with most of these differences achieving statistical significance at $\alpha = 0.01$. The positive effect of videos and flipping was further validated by the fact that the sections did not differ significantly in their incoming GPAs (although the treatment group's average GPA was slightly higher). These results provide the strongest evidence identified from the literature in favour of using videos to flip classes: not only are the results conclusive, but the study design and execution are beyond reproach. The only potential caveat with this study is that the sample size was quite small, with only two sections and 46 students in total, and of course that these results only reflect one group of computer science students from one university. Still, framed by all of the other evidence provided in this literature review, the results from Day and Foley (2006) provide a solid theoretical background to suggest that using videos should be an effective means of getting students to prepare before class for activities that will take place in class, and, most importantly, that this flipped class methodology can have important beneficial effects on student learning.

4. CONCLUSIONS

As elaborated in the previous three sections, numerous research studies have been conducted over the past several years to examine different facets of vodcasting.

These have identified that students tend to have very positive affective and cognitive attitudes towards the methodology, and that a majority of students will use these resources to improve their learning (Kay, 2012). Most importantly, though, it appears that providing students with videos, be they for review, as a supplement, or pre-class for the purposes of a flipping-style methodology, can have positive effects on direct measures of student learning gains (Day & Foley, 2006; O'Bannon *et al.*, 2011; Traphagan *et al.*, 2010; Vajoczki *et al.*, 2010; Walker *et al.*, 2011).

However, what remains unclear is whether a flipped class methodology itself could lead to such learning gains, or whether providing videos to view before class is an integral part of this effect. Evans (2008) suggests that students perceive increased value in vodcasts as compared with readings, but Mann *et al.* (2009) found the opposite trend; neither of these studies are solid enough to stand up on their own, though, meaning a large amount of uncertainty surrounds this issue. Given the potentially prohibitive time demands associated with creating content videos for pre-class viewing, instructors need to know that their time and efforts will be rewarded not only with improved student affect, but indeed with measurable gains in summative assessment scores. Providing a workable answer to this question was the major goal of the present research.

CHAPTER FOUR

RESEARCH METHODOLOGY

1. QUESTIONS AND HYPOTHESES

Centered within the context of a flipped class pedagogical approach (this concept is described in the previous chapters), this research examines whether providing vodcasts for students to view before class is a more effective method of getting them to learn the basic facts and concepts and come to class prepared than requiring them to do readings. Stemming from this, the overall hypothesis being tested is that vodcasts are more effective pre-instructional tools than assigned readings. The independent variable in this study is the use of videos as a pre-class instructional tool, which establishes the treatment group as the class that was provided videos to view before class (Class A), while the control group is the class that was assigned readings from the textbook (Class B).

In this context, the ‘effectiveness’ of readings and videos refers to their ability to promote student learning gains, and, in this study, is assessed by testing several subsidiary hypotheses, each with a specific dependent variable:

- H1. Students provided with videos should come to class with a greater grasp of basic content knowledge than students who are assigned readings;
- H2. Students watching videos should be more successful at answering higher level Bloom’s taxonomy questions and addressing more cognitively complex problems before and during class;
- H3. Students that watch videos should display greater learning gains on high-value summative assessments than students who are only assigned readings;

- H4. Students provided with videos should need less time to adequately prepare for class than students from the assigned readings section;
- H5. Students provided with videos should be more likely to actually do the work required before class than students from the assigned readings section;
- H6. Students provided with videos should perceive their overall workload as more manageable than students from the assigned readings section;
- H7. Students provided with videos should generally have more positive attitudes towards their learning experience in the course than students from the assigned readings section.

2. RESEARCH DESIGN

This research project employed a quasi-experimental design based on separate treatment and control group sections. Given the constraints of conducting research within an educational environment, this study design was best suited for addressing the types of hypotheses outlined in the section above. Data were collected using a combination of student scores on various assessments and student responses to targeted survey questions, as well as impromptu asynchronous interviews with several students who dropped the course.

2.1 Study Set-Up

This study used a pre- and post-test non-equivalent groups design involving a convenience sample of two General Biology 1 courses, offered to regular Science students during the winter 2013 semester at Vanier College. Both courses (Classes A and B) were taught by the same instructor using a flipped class methodology, where students were expected to engage in the initial transfer of knowledge outside of the classroom, leaving class time free for activities and assignments. All factors were kept as constant as possible between the two sections, employing identical schedules, pre-class quizzes, activities, labs, and assessments, all in an attempt to establish the

major difference between the two courses as the independent variable of this study: assigned readings before class for one section (Class B), pre-class videos to replace (or complement) assigned readings for the other (Class A). Thus, Class B was only provided with a list of readings, while Class A had this list of readings as well as access to videos for each class.

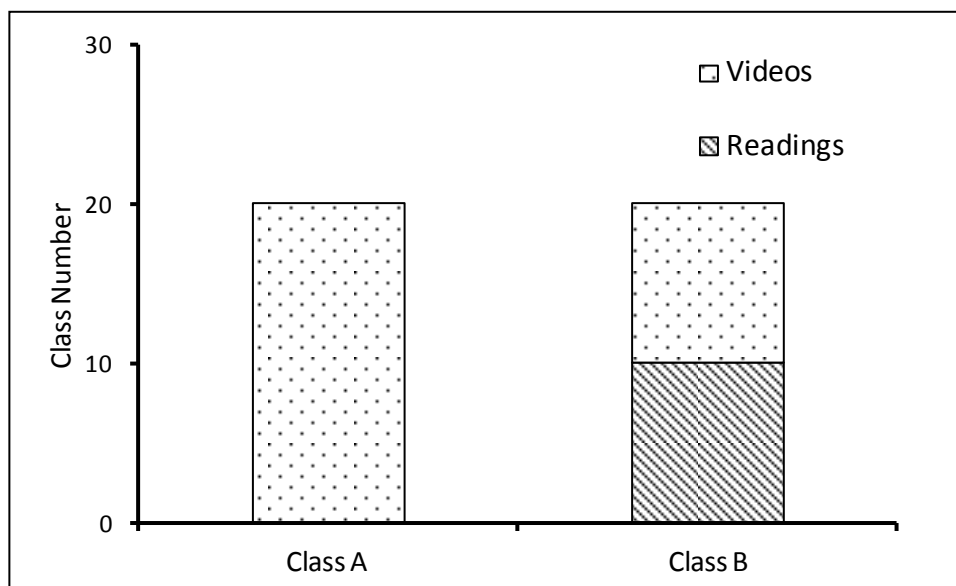


Figure 1. Diagram of the overall study setup

The study was undertaken during the first four units of the General Biology 1 course, which comprised the first 20 of 30 total classes in the course. The initial study design for classes 10-20 (units 3 and 4) entailed swapping the video and readings groups, such that the Class A that had videos during the first two units would only be provided with readings, while the initial readings group, Class B, would now have access to videos. However, as the first two units of the course drew to a close, a decision was made by the author to provide videos to both groups, based on indications from the classes that readings alone consisted of too high a workload for the students (these indications are described in the following sections). The resulting overall study setup is displayed in Figure 1. It's important to note here that

the decision to use videos for both groups during units 3 and 4 meant that only 16.7% of the students' final grades were assessed under the different experimental methodologies. Thus, any potential disadvantage to students in the readings group would actually have been rather minor within the context of the overall course.

Consequently, for units 3 and 4 of the course, both of the author's groups were subjected to exactly the same pedagogical approach. This adapted study design obviously introduced two important pitfalls: not being able to assess the effect of switching from videos to readings, and of course not being able to directly contrast videos and readings for units 3 and 4, which meant that hypotheses H1-H3 were only tested based on units 1 and 2. The modified study design did, however, make it possible to directly compare the performance of both groups under the same conditions, which provides context for the results obtained during the first two units of the course. The result is the inclusion in the study of a novel subsidiary hypothesis:

H3-A: Students who were initially only provided with readings should benefit from being granted access to videos in a similar way to those students who had access to videos from the beginning, and should therefore demonstrate an increase in learning gains during units 3 and 4 similar to those hypothesized for the videos group (H1-H3) during units 1 and 2, thus bringing both groups up to the same level.

2.2 Sample/Participants

Participants in the study were the students enrolled in the two General Biology 1 courses. Enrolment in each course was slightly lower than predicted, at 39 students in Class A and 33 students in Class B, for a total enrollment of 72 students. The overall sample was one of convenience, in that the students self-registered for classes. Despite this, however, it appears as though there were minimal issues with internal validity. For one, General Biology 1 is a required course for a Science

diploma, meaning all Science students need to complete it at some point, and it seems unlikely that students included in this study decided to take the course during the winter 2013 semester for reasons relating to the variables under examination. Further, information on the study or the various teaching methodologies was not available during registration, meaning students did not select their particular class based on the presence or absence of videos. Finally, students were not informed of the existence of this study until after the first two units, providing some measure of control against across-section influences. This last measure, along with the rest of the study, received ethical approval from Vanier College's Research Ethics Board (the ethical clearance certificate is provided in Appendix C).

Table 1
Study Sample Sizes, Group Demographic and Aptitude Comparisons

Class	A	B
A. Sample Sizes		
Class Enrolment	39	33
Permission for Study	37	31
Permission for Grades	36	30

Statistics	Mean	SD	Mean	SD	Test Statistic	Sig. (2-tailed)
B. Aptitude					<i>t</i>	
High School Science	84.23	4.06	82.93	4.71	0.99	0.38
College Science	70.60	9.91	72.53	7.02	0.26	0.46
Pre-Test	3.89	0.21	3.53	0.26	1.09	0.28
C. Demographics					χ^2	
Age					3.10	0.38
Semester in College					3.27	0.20
Program					0.23	0.63
Gender					6.33	0.18
Ethnicity					0.17	0.92

At the end of the first two units, students were provided with the details of the study, and were asked to complete both an anonymous survey and a demographic questionnaire through which they would provide consent for inclusion in the study

(the video class survey is included as Appendix A, the questionnaire and consent form is included as Appendix B). The resulting sample sizes of consenting students per class are displayed in Table 1. In the questionnaire, students were also asked to provide consent for the author to obtain their high school and college science averages for the purposes of assessing homogeneity across the groups. Finally, on the first day of class, students completed a short pre-test survey to assess their 'previous biological knowledge'. This pre-test was used to help the instructor define in-class groups, but is also a further measure to control for the initial knowledge and cognitive abilities of the study's treatment and control groups. The student high school and college science grades, as well as the results of the demographic questionnaire and the pre-test, are all displayed in Table 1. Overall, no statistically discernible differences were identified between the two groups for any of these variables.

Despite the convenience sample of Vanier College students, issues of external validity are likely negligible, at least in terms of generalization to Vanier Science students. The study sample included 33% (2 of 6) of the General Biology 1 courses taught during the winter 2013 semester, and a comparison of the demographic data obtained for the two study groups to those from the pool of remaining students identified no meaningful differences. Generalization to the larger population of English College Science students is not quite as clear, however. Vanier College displays a greater degree of ethnic diversity among its Science students than other English colleges in Quebec (anecdotal observations from backgrounds and mother tongues of ESL students; M. Bucaro, English Department, Vanier College, personal communication, December 18, 2013), as well as lower overall student high school averages (Vanier: $77.9\% \pm 0.18$ SEM; other Anglophone colleges: $80.3\% \pm 0.15$ SEM; Service Régional d'Admission du Montréal Métropolitain, 2013). While neither of these factors necessarily invalidate any of the conclusions from this research, it is important to keep them in mind when interpreting the results. Also noteworthy is the fact that the college system in the province of Quebec (Collège d'enseignement général et professionnel, or CEGEP, which translates to 'general and vocational

college’) is unique in North America, with the colleges accounting for students’ last year of high school (grade 12) and their freshmen year of university. Consequently, participants in this study consisted of both high school and university-aged students, all of whom were studying in a unique educational system. Thus, one should be cautious in generalizing the results from this study.

2.3 Variables and Instruments

The independent variable in this study is the use of vodcast videos as a pre-class instructional tool. The videos used were predominantly obtained through YouTube, but also included videos created by the author. Overall, 56 videos were provided to the students, with an average of three assigned videos per class, and with lengths ranging from 1:48 to 17:26. Of the 56 videos, 34 were obtained from the YouTube account ‘bozemanbiology’, where a Biology teacher from Montana has created and uploaded over 100 high quality college level Introductory Biology content videos. Fourteen further videos were obtained from various other YouTube accounts, including ‘Andrew Douch’, ‘Kristina Gremski’, ‘mjmom827’, ‘braingenie’, ‘ppornelubio’, ‘ScilMedia’, ‘Johnny Clore’, ‘ScScienceVid’, and ‘360 Edmlaurence’. Finally, three videos were publisher-provided animations, and the remaining five videos were created by the author using PowerPoint, Prezi, Jing screen capture software, and Windows Movie Maker. The videos were all selected or created by the instructor to provide the students with a comprehensive package of the content knowledge required for each particular class.

If the video class was the independent variable treatment group, then the control group consisted of the class that was only provided assigned readings from the textbook. The specific list of readings was compiled by the author several semesters previous to the study, and is a highly detailed outline of both the readings and corresponding expected learning outcomes for each successive class in the course, linking both to the hard copy text and to the online eBook. The video group

was also provided with this list (including the learning outcomes), but were informed that all of the content knowledge they required could be obtained from the videos. Indeed, the overall ‘content’ for both groups was essentially the same (it was impossible to completely cut out all possible extraneous information from the list of readings, but this was trimmed down sufficiently as to be very close in terms of total content to what was presented in the videos), and thus the only difference between the treatment and control group was access to pre-class videos.

As outlined in section 2.1 from this chapter, the broad hypothesis tested in this study is that vodcasts are more effective pre-instructional tools than assigned readings. However, the actual study consists of several subsidiary hypotheses, also enumerated in section 2.1. Data to test these hypotheses were collected using the following instruments and methods:

- H1. Students were assigned (i.e., worth micro-marks) pre-class online Moodle quizzes based on the videos/readings, where between 6-8 of the questions (out of 10) were of the basic recall-understand variety. Then, at the very beginning of class, students were asked several questions using classroom response system technology (clickers), also worth micro-marks, where 4-5 (out of 8-10) consisted of low-level Bloom’s questions, designed simply to test student recall and basic comprehension of material they should have encountered before class. All of the questions used were compiled by the author and other instructors in the College over various years of practice, and were either written personally or obtained and/or modified from publisher testbanks. A sample of the questions used for the first class is provided in Appendix D.
- H2. This hypothesis was tested using exactly the same methodology as the previous hypothesis, with 2-4 pre-class Moodle questions and 4-5 beginning of class clicker questions addressing apply-analyze levels of Bloom’s taxonomy. As for H1, all of the questions used were compiled by the author and other instructors in the College over various years of practice, and were

either written personally or obtained and/or modified from publisher testbanks. A sample of the questions used for the first class is provided in Appendix D.

H2 was also examined using in class activities and formative assessments. These were designed during the semester preceding the study by the author and two other instructors from the College, and challenge students at various more cognitively complex levels of Bloom's taxonomy. The activity used for the first class is provided in Appendix D as a sample.

H3. This hypothesis was tested using four unit exams, each of which assessed four or five classes of material. These exams assessed the students' abilities to answer questions of different styles (multiple choice, short answer, and essay) and of differing levels of cognitive complexity, all of which they were exposed to over the course of the particular unit. The same unit tests were used in both classes for every unit. The tests were compiled using questions written by the author and other teachers from the department, as well as questions obtained and/or modified from various publisher testbanks. All of the tests were graded blindly (i.e., without identifying names or section) by the author to ensure equitable and unbiased grading. The first unit test is included as a sample in Appendix D.

H3-A: The prediction from H3-A is that, relative to their scores from units 1 and 2, students from the initial readings group should score proportionally higher across all measures when provided with videos than students from the initial videos group. Consequently, this hypothesis was tested using the same methods outlined for H1-H3, save for one caveat: no distinction was made between low and high cognitive level questions during units 3 and 4, so only total scores were collected for each assessment. H3-A also incorporated the cumulative final exam, which was constructed and graded in the same way as the unit tests.

H4-7: These hypotheses were tested by means of an anonymous student survey, which was provided to the students in paper form following the second

summative unit test. Students were provided with an incentive for participation in an attempt to increase response rate (a raffle for a \$100 prize); this tactic resulted in a response rate of 85% for Class A and 82% for Class B, or 33 video class responses and 27 readings class responses.

The video group version of the survey is included as Appendix A, but basic details of both surveys are displayed in Table 2. The video group survey consisted of 44 items, while the readings group survey consisted of 41 items. All questions were closed-ended. Table 3 presents Cronbach's alphas for the four survey areas which employed multiple-item measures of a particular unidimensional construct.

Table 2
Description of Video and Readings Group Surveys

Area	Example Question	Videos Section: # of items	Readings Section: # of items
Student Demographic Characteristics	Information Presented in Table 1	3 closed-ended	3 closed-ended
Self-Reported Completion of Pre-Class Assignments (Videos, Readings, Quizzes)	The first unit of this course (classes 1-5) required you to watch 16 pre-class videos. Of these, how many did you watch in their entirety?	16 closed-ended	13 closed-ended
Perception of Effort and Workload	Indicate the amount of effort you feel you put in to preparing for each class by watching videos and completing the Moodle quizzes.	4 closed-ended	4 closed-ended
Preparation for Unit Tests	Indicate how well prepared you felt you were for the FIRST unit test just before writing it.	6 closed-ended	6 closed-ended
Comparison of Strategies *	Indicate how much you would have preferred this classroom unit if readings were assigned before the class instead of videos, but the rest of the approach (Moodle quizzes, in-class activities, etc.) remained the same.	5 closed-ended	5 closed-ended
Effectiveness of Strategy:			
Clarity and Ability to Help Students Understand *	The pre-class videos were clear and easy to understand.	4 closed-ended	4 closed-ended
Pre-Class Assignments are Useful Study Tool *	The pre-class videos were a useful study tool when preparing for unit test 1.	3 closed-ended	3 closed-ended
Pre-Class Assignments Help Prepare for Class *	The pre-class videos and Moodle quizzes allowed me to come to class prepared for the activities.	3 closed-ended	3 closed-ended

* Survey area with multi-item measures of a particular unidimensional construct

Table 3
Cronbach's Alpha for the Four Multi-Item Measures in each Survey

Area	Cronbach's Alpha
Comparison of Strategies	0.72
Clarity and Ability to Help Students Understand	0.71
Pre-Class Assignments a Useful Study Tool	0.82
Pre-Class Assignments Help Prepare for Class	0.87

By the end of the second unit of the course, six students (out of 39, or 15%) had dropped out from Class B, or the control readings section. This high attrition rate was unprecedented in the author's previous six years as a college teacher, and was in stark contrast to the video section, which didn't lose any students. While certain indicators (pre-test, pre-class quizzes, clicker questions) suggest that two of the six students who dropped out may in fact be academically strong students, it remains that the high drop rate for the readings class was the major impetus for the author's decision to provide videos to both groups during units 3 and 4. For the remaining four students, not enough information was collected during their tenure in the class to properly ascertain whether their departure created a possible bias with regard to the overall academic strength of group B. Fortunately, as this group of four students was ultimately only a small sample from the class (~10%), any such bias would likely have been negligible. It's also important to re-iterate here that no information from these six students was incorporated into the statistical analysis at any point (Table 1).

Given the goals of this study, it appeared potentially important to understand why so many students dropped the course from the readings section. To this end, the author used email communication to asynchronously interview the students from Class B who dropped the course. Students were asked to indicate how much time they spent on average preparing for each class, how much time they spent in total preparing for unit 1, and to use a 7-point Likert scale to rate the amount of effort they put in to the course as well as their perception of the overall workload. Finally, students were asked an open-ended question about whether effort and workload requirements factored in to their decision to drop the course. While most of these questions were the same as those on the student survey (described below), the data obtained from the interviews were examined separately, to provide a snapshot viewpoint of this particular subset of students.

2.4 Data Analysis

2.4.1 Student Scores

Testing H1 and H2 involved comparing ratio scale student grades on various pre- and in-class assessments, H3 was examined using ratio scale scores on summative assessments, and H3-A was an extension of the first 3 hypotheses and thus used the same data. All statistical analyses were conducted using SPSS. While the expectation would be that such data would meet with parametric assumptions, it was necessary to reject this null hypothesis at $\alpha = 0.05$ for several of the nominal Moodle, clicker, and activity groupings (a complete presentation of tests for parametric assumptions is provided in Table 6, found in Appendix E); all of the test scores did satisfy the assumptions, however. With this discrepancy in mind, on closer examination, it became clear that the assumptions were violated because of student absenteeism, as several students missed more than one class or failed to complete more than one Moodle quiz (all students were present for the tests). These students received a grade of 0 for the missed assessments, which resulted in an artificially low cluster of grades for each of the pre- and in-class assessments.

To overcome this problem, the data were normalized by eliminating from the data set those students who missed more than one class (and thus the clicker questions and activities completed in those classes) and/or more than one Moodle quiz. The resulting data set consisted of 32 students in Class A and 24 in Class B. To ensure that the removal of these students didn't artificially affect results (for example by removing the weaker students who might be more inclined to miss assessments), the average grades for each of the eliminated data points, ignoring the zeros for missed assessments, were compared to the overall averages for each of the categories. In all but one case, the removed student averages were within one standard deviation of the group average, suggesting that removing these data points had minimal effect on the overall results.

Normalizing the data in the manner described above ultimately resulted in all of the groups satisfying the assumptions of normality, again at $\alpha = 0.05$ (a complete presentation of tests for parametric assumptions on the normalized data is provided in Table 7, found in Appendix E). Therefore, independent sample *t*-tests, assuming equal variances, were used to test out H1, H2, and H3. Despite the directionality inherent in most of the hypotheses, all conclusions were drawn based on two-tailed significance measures with $\alpha = 0.05$.

The same normalized data were used to test H3-A, and so direct grade comparisons for units 3 and 4, as well as for the final exam, were also conducted using independent sample *t*-tests. However, the data were additionally manipulated in order to identify whether a relative change in score had occurred between the two groups as a result of the initial readings group being granted access to videos. For each assessment, total scores for units 1 and 2 were subtracted from the total scores for units 3 and 4, to provide ‘difference between units’ measure for each student. These novel scores were also found to satisfy the assumptions of normality, and so independent sample *t*-tests (with both equal and unequal variances; see Table 7) were used to determine whether the initial readings group demonstrated a more positive change in grade between the two units than the videos group. As for H1-H3, all conclusions were drawn based on two-tailed significance measures with $\alpha = 0.05$.

2.4.2 Survey Data

H4. Students were asked to estimate the amount of time, rounded to the nearest half hour, that they spent per class watching videos and/or doing readings and completing Moodle quizzes for both units 1 and 2. Subsequently, they were asked to estimate the total amount of time they spent preparing for all of their classes combined during a particular unit, again for both units 1 and 2. The raw data compiled from student responses failed to satisfy normality assumptions (Table 8 in Appendix E), but a cursory glance quickly identified numerous implausible

responses. For example, one student indicated that they would spend 18 hours preparing for each class, and that they spent 80 hours overall preparing a four class unit (i.e., essentially 80 hours in two weeks). Extreme outliers were therefore identified using SPSS and removed from the data set, which reduced the total sample from 60 to 53. Despite this measure, normality assumptions were still not met (Table 9 in Appendix E; the likely explanation for this is that logically implausible responses were not statistically identified as extreme outliers, and were thus maintained in the data set), and so H4 was examined using independent sample Mann-Whitney U tests, with group as the independent variable and the various times as dependents.

H5. Students were asked to indicate how many of the pre-class videos and/or readings they completed, as well as how many of the Moodle quizzes they attempted or completed. These were both then tallied as percentages. For students from the video class, it was possible to receive credit for completing a pre-class assignment if they only did the readings but did not watch the video, but they didn't receive extra credit for doing both. Students from the readings class could only receive credit for completing readings. Finally, any students that indicated they had only partially completed an assignment would have been given 50% credit, but this did not happen.

The vast majority of responses to the questions resulted in 100% data points, and so the total data set did not meet assumptions of normality. Thus, H5 was tested using independent sample Mann-Whitney U tests, with group as the independent variable and the two 'percent complete' measures as dependents.

H6. Using a 7-point Likert scale, students were asked to indicate the amount of effort they felt they had put in preparing for classes during units 1 and 2, as well as how heavy they felt their workload was. The interval scale data collected failed to satisfy normality assumptions (Table 10 in Appendix E), so H6 was tested using independent sample Mann-Whitney U tests, with group as the independent variable and student Likert responses as dependents.

H7. Four unidimensional constructs were incorporated into the student survey to assess students' general perceptions of, and attitudes toward, their particular instructional strategy. These four survey areas included 15 closed-ended questions, and are identified in Table 2. These were all either in 5-point or 7-point Likert-scale format, and thus provided interval scale data. However, none of the response sets met with the parametric assumption of normality (Shapiro-Wilk W , sig. < 0.01), and therefore any relevant comparisons between the video and readings groups were undertaken using independent sample Mann-Whitney U tests, with group as the independent variable and student Likert responses as dependents.

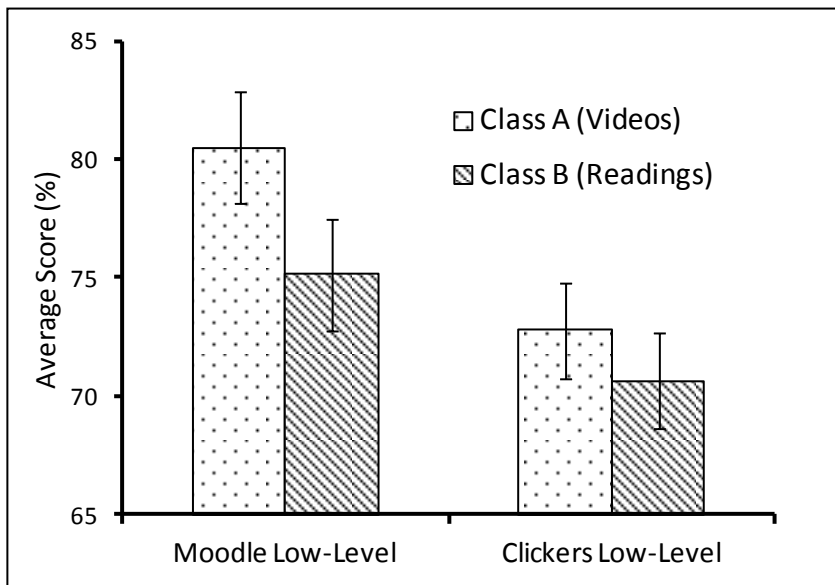
CHAPTER FIVE

PRESENTATION AND ANALYSIS OF RESULTS

1. STUDENT SCORES

The initial data analyses to test H1-H3 were done separately for units 1 and 2 for each of the particular measures. However, no statistically significant differences were identified between units 1 and 2 for any of these measures, and so the data were pooled. Consequently, results presented for H1-H3 represent units 1 and 2 combined.

1.1 H1

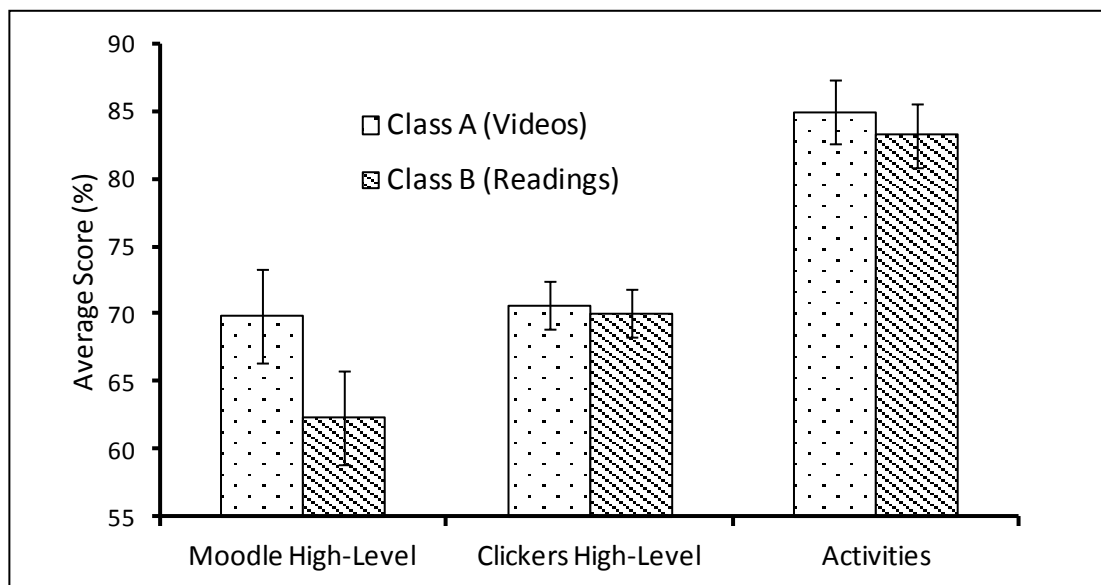


Error Bars Represent 95% Confidence Intervals of the Means

Figure 2. Average scores on content-knowledge-based (low level) pre- and in-class quizzes for units 1 and 2

Figure 2 illustrates that students granted access to videos before class were able to score higher on the low-level questions from both the pre-class Moodle quizzes and the in-class clicker questions. However, only the difference between the Moodle question scores was statistically significant ($t = 2.278$, $df = 54$, $p = 0.027$).

1.2 H2

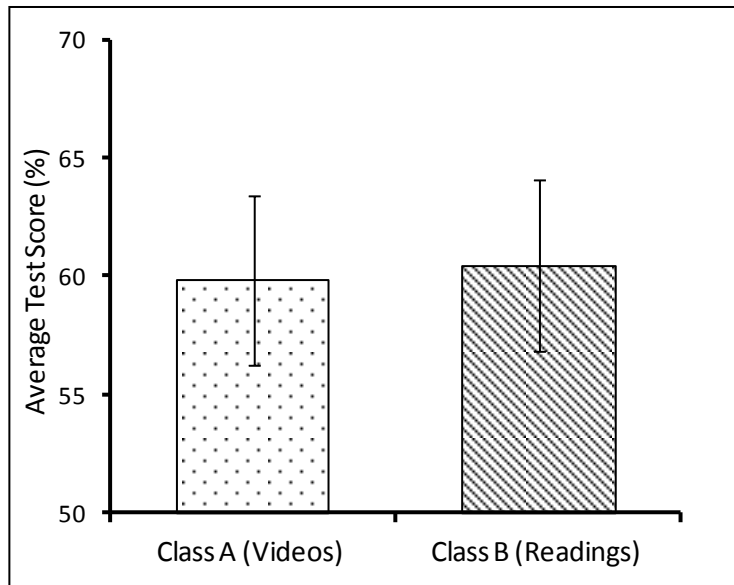


Error Bars Represent 95% Confidence Intervals of the Means

Figure 3. Average scores on questions requiring students to apply concepts and analyze data to solve problems (high-level) during pre- and in-class quizzes as well as activities for units 1 and 2

Figure 3 indicates that, once again, students granted access to videos before class were able to score higher, this time on high-level questions from the pre-class Moodle quizzes and in-class clicker questions, but also on the in-class activities. The only observed difference was with the Moodle question scores and this difference was statistically significant ($t = 2.199$, $df = 54$, $p = 0.032$).

1.3 H3



Error Bars Represent 95% Confidence Intervals of the Means

Figure 4. Average scores on summative tests for units 1 and 2

Figure 4 demonstrates almost equal average scores over the units 1 and 2 tests for both groups, with the readings group having a slight, but not statistically significant, edge (Class A: $\bar{x} = 59.83$, $sd = 16.10$; Class B: $\bar{x} = 60.47$, $sd = 12.50$; $p = 0.547$). The unit tests are the only measure from units 1 and 2 where the readings group scored higher than the videos group.

1.4 H3-A

Data were contrasted between units 3 and 4 across all measures, and no significant differences were identified between the average scores for each group. Therefore, data were pooled from units 3 and 4 in a similar manner to how this was done for units 1 and 2, and H3-A was tested using the averages from units 1-2

combined and the averages from units 3-4 combined, as well as scores on the final exam.

Table 4
Comparison of Average Percent Scores Across All Measures for Units 1-2 and 3-4

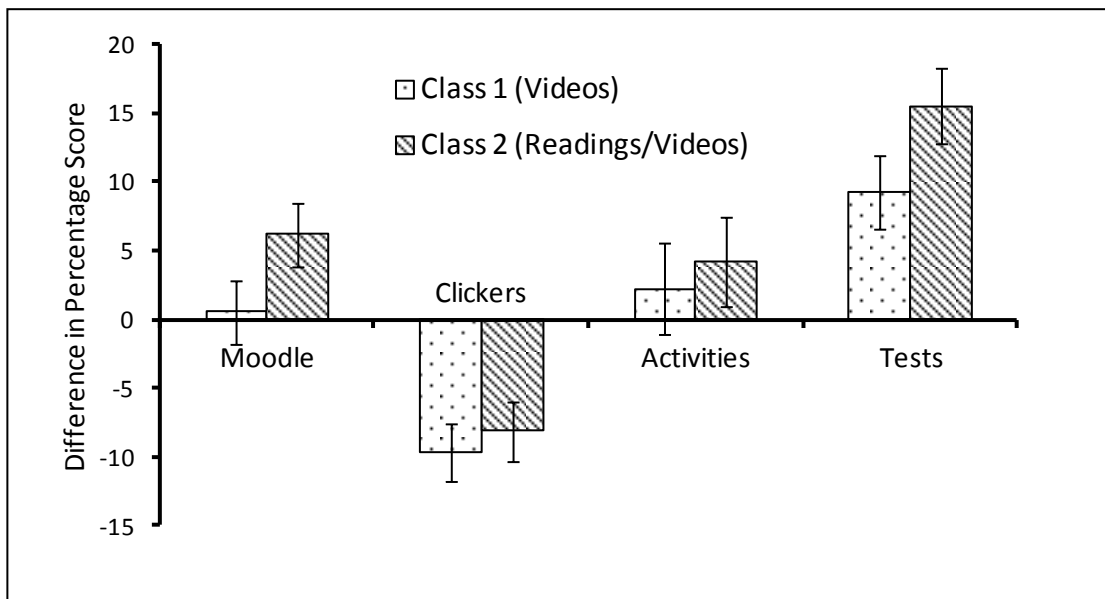
Measure	Moodle		Clickers	
	1-2	3-4	1-2	3-4
Class A	77.6 (9.02)	78.1 (11.49)	72.2 (5.78)	62.6 (8.64)
Class B	71.6 (8.97)	77.8 (9.23)	70.4 (5.83)	62.3 (6.78)

Measure	Activities		Tests		
	1-2	3-4	1-2	3-4	Final
Class A	84.9 (11.17)	87.1 (7.05)	59.8 (16.10)	69.3 (12.69)	62.0 (15.81)
Class B	83.2 (5.98)	87.4 (5.32)	60.5 (12.50)	76.6 (11.14)	69.9 (8.74)

Cell Values: %(sd)

Highlighted boxes indicate rejection of the null hypothesis ($\alpha = 0.05$)

Class A: Videos Group; Class B: Initial Readings Group, Switched to Videos for Units 3-4



Error Bars Represent 95% Confidence Intervals of the Means

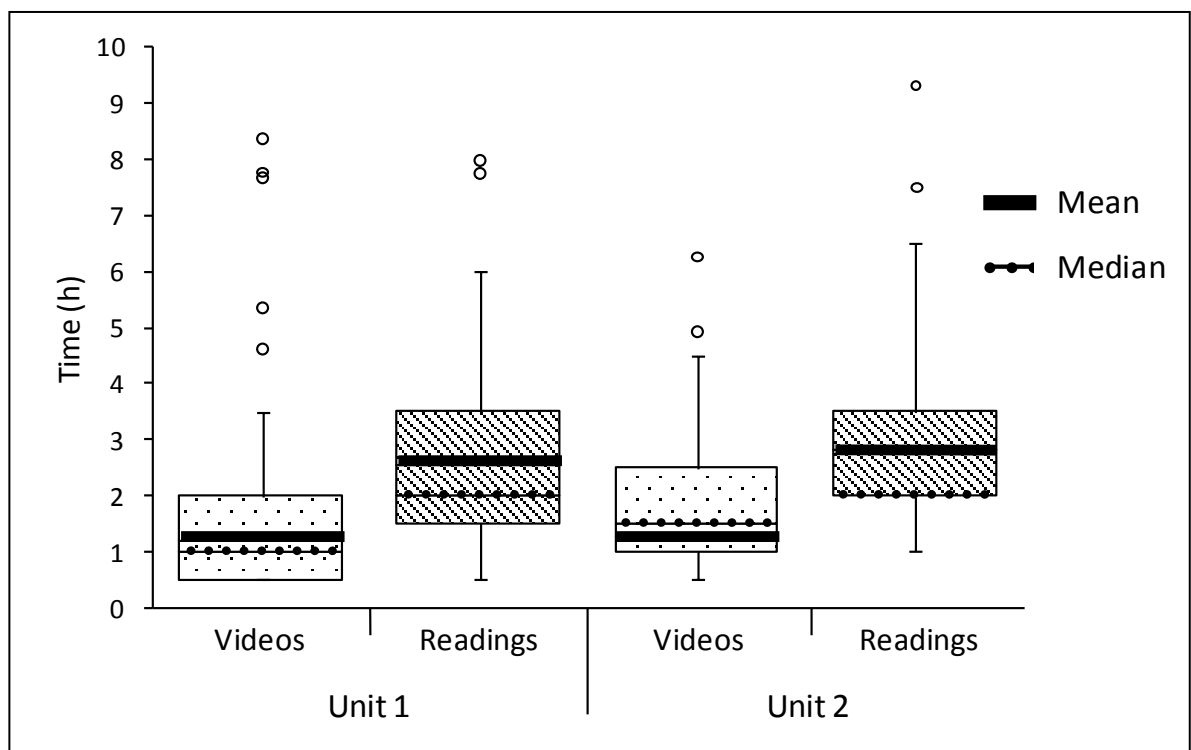
Figure 5. Difference between average percent scores obtained during units 1-2 and 3-4 for each measure

Table 4 demonstrates that Class A and Class B achieved nearly identical average scores during units 3-4 on the Moodle, clicker, and activity assessments. The unit tests and the final were in strong contrast, however, as Class B scored significantly higher on these than class A (unit tests: $t = -2.586$, $df = 64$, $p = 0.012$; final exam: $t = -2.443$, $df = 64$, $p = 0.017$). In fact, after being provided with videos to watch, Class B demonstrated more positive gains (for clickers this manifested as less negative) across all measures during units 3-4 than students from Class A (Figure 5), although only the differences between the Moodle and unit test score differences were statistically significant (Moodle: $t = -2.449$, $df = 54$, $p = 0.018$; unit test: $t = -2.292$, $df = 54$, $p = 0.025$).

2. STUDENT SURVEYS

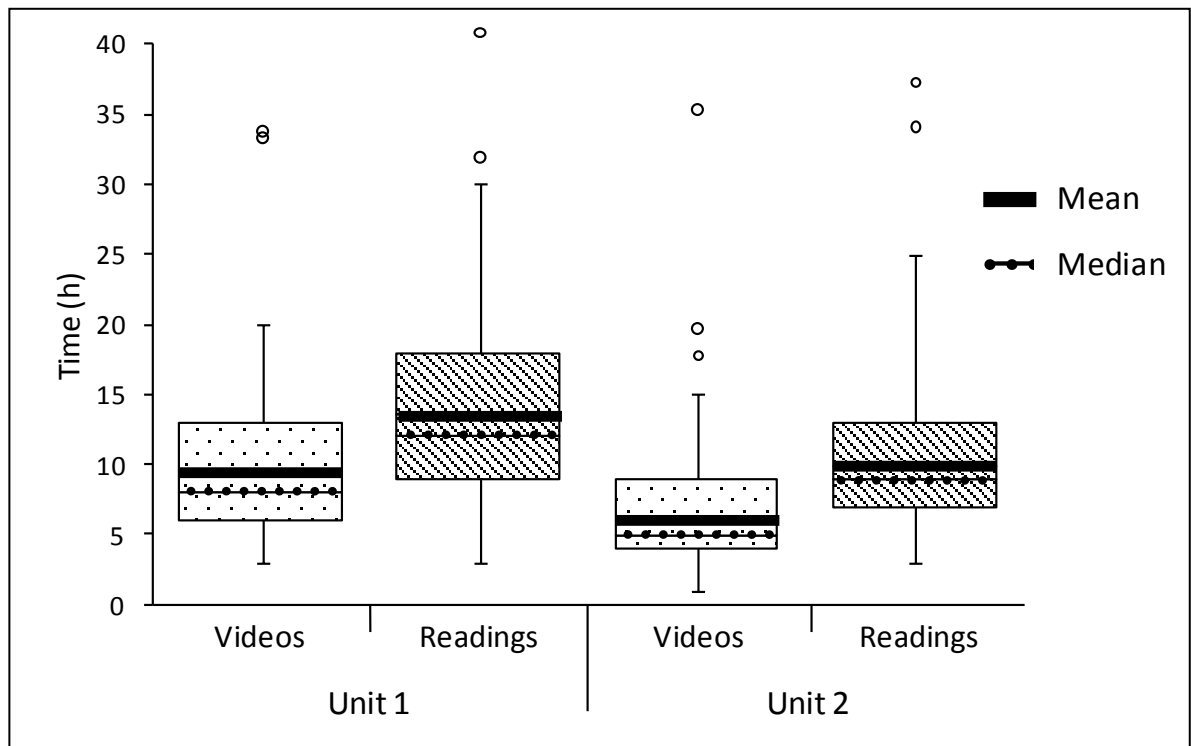
Students were asked to complete anonymous surveys in order to test out hypotheses about realized and perceived effort and workloads. In particular, they were asked to estimate the amount of time that they spent per class and for the entire unit watching videos and/or doing readings and completing Moodle quizzes.

2.1 H4



Circles Represent Outlier Points, As Identified by SPSS. Extreme Outliers Were Removed from the Distributions

Figure 6. Box plots summarizing responses for time spent preparing per class during each unit



Circles Represent Outlier Points, As Identified by SPSS. Extreme Outliers Were Removed from the Distributions

Figure 7. Box plots summarizing responses for time spent preparing overall during each unit

As predicted, students appear to require more time to prepare for class when they only have readings available as learning materials. The box plots from Figure 6 clearly indicate that student reported mean and median times spent preparing for each class were higher for the readings group over both units, and a similar result is displayed in Figure 7 for the total amount of time spent preparing during a unit. Only the 'time per class' difference for unit 2 achieved statistical significance, however ($p = 0.011$), although all of the other differences did approach this benchmark ($0.1 > p > 0.05$).

2.2 H5

Table 5
Percentage of Pre-Class Assignments Completed

	A. Pre-Class Preparation Completion		B. Pre-Class Quiz Completion	
	Unit 1	Unit 2	Unit 1	Unit 2
Class A	99.35 (3.22)	94.97 (18.97)	98.72 (5.70)	95.72 (11.92)
Class B	90.26 (17.69)	88.03 (17.91)	98.54 (5.83)	96.18 (18.59)
<i>sig.</i>	0.001	0.008	0.832	0.169

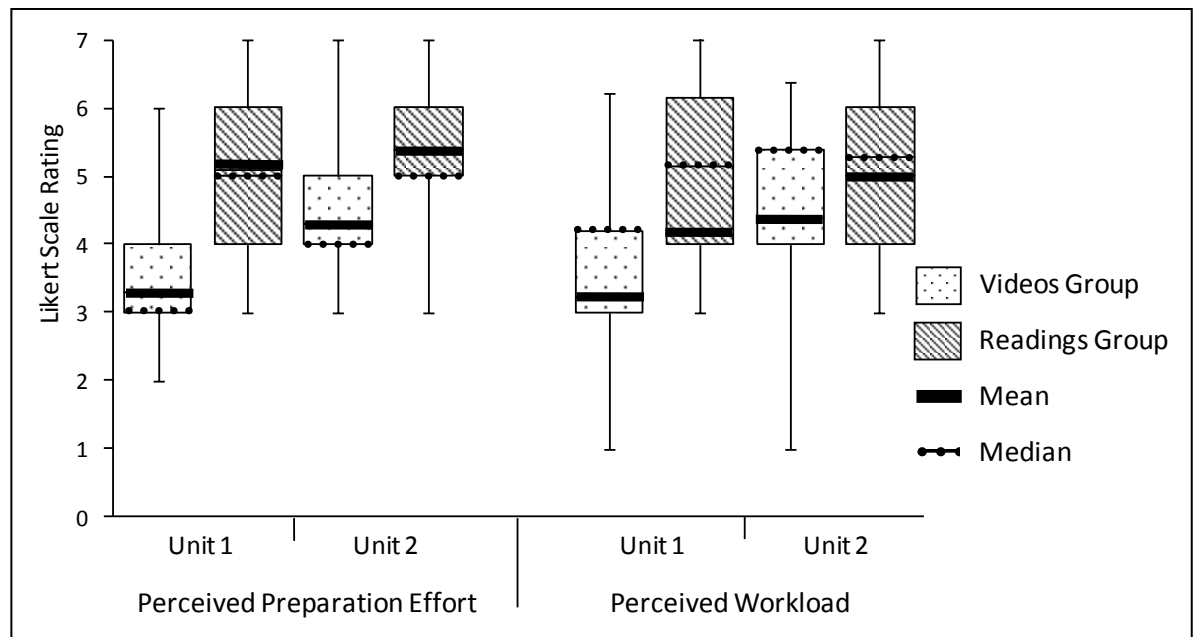
Class A and Class B Cell Values: %(sd)

Class A Pre-Class Preparation: Watching Videos (Option to do Readings)

Class B Pre-Class Preparation: Doing Readings

Data from the student surveys also provide support for H5. For both units 1 and 2, students from Class A completed significantly more of their pre-class preparations than did students from Class B, although both classes appeared to drop off slightly in unit 2 (Table 5A). Despite these differences in preparation, however, most students from both groups completed all of the pre-class quizzes, resulting in no differences between the groups for this measure (Table 5B).

2.3 H6



Likert scale responses where 1 was very low, 4 average, and 7 very high

Figure 8. Box plots summarizing responses for perceived effort per unit, and perceived workload per unit

Following somewhat logically from the results for H4, students from the readings group perceived that they had to put in more effort to prepare for class than did students from the videos group. Further, readings students also perceived their workload to be higher over both units 1 and 2 (Figure 8). All of the differences were highly statistically significant ($p < 0.001$), except for the difference in workload perception for unit 2, which was only slightly below the α level ($p = 0.02$).

2.4 H7

When students were asked to rate either videos or readings as useful tools for preparing for class or studying for tests, no discernible difference emerged between the two strategies. Rating these on a scale of 5 (1 highly negative, 3 neutral, 5 highly positive), students seemed only marginally satisfied with either resource, with averages between 3.20 and 3.33, when students were asked if watching/reading before class helped them complete Moodle quizzes or be prepared for activities. Responses were similarly neutral and indistinguishable when students were asked if videos/readings were useful study tools for either of the unit tests, with the response averages ranging from 3.02 to 3.27. Thus, students do not seem to favour either strategy as a means for actually preparing for other assessments, and appear somewhat lukewarm on the strategies in general.

In contrast, in answering questions pertaining more to clarity, understanding, and affect, a clear distinction emerged between how the students perceive the two approaches. When asked whether the videos/readings were clear and easy to understand, the video response average was 3.83, while the reading average was 2.95 ($p < 0.001$); conversely, when asked whether the resource was difficult to follow and confusing, the video average was 1.81 and the reading average was again 2.95 ($p < 0.001$). Students also felt they could understand the basic concepts more easily from watching videos (videos 3.52, readings 3.21), but this difference was not statistically significant ($p = 0.121$). Finally, students found the videos more fun and entertaining than the readings (videos 3.78, readings 2.62, $p < 0.001$).

The last subset of questions asked the students to compare their experience with a particular strategy to what they might expect from the other strategy. This line of questioning uncovered a particular trend: students who didn't have access to the videos were generally more positive on these than those students that had them. When asked to rank how much more effective they believe readings were as

compared to videos in terms of helping them understand biological concepts, students from the videos group averaged a score of 2.69, which, while edging towards the negative (i.e., suggesting videos are more effective), is far from an overwhelming statement of support. However, these students were also clear that they felt readings alone would not be enough, with a score of 1.81 when asked to rate a readings-only class. Conversely, students from the readings group felt rather strongly that pre-class videos would be more effective than readings at conveying concepts (4.26), and that they would have preferred the class if only videos were provided (4.29).

Finally, the students were also asked to compare the two methods with regard to time demands. Students from the video group were asked whether the videos required *less* time and effort than readings, while students from the readings group were asked whether the readings required *more* time than if they had videos. Either way, agreement that readings require more time than videos would have prompted a high Likert response, and the expectation was of a similar average from both groups. Instead, the videos group produced an average of 3.02, while the readings group averaged 3.87, which was a statistically significant difference ($p = 0.002$). These numbers indicate that students from the readings group believed that videos would require less time than readings, but that students from the videos group did not feel that the videos offered them any discernible time advantage.

3. ASYNCHRONOUS INTERVIEWS

Six students who dropped the course from the readings section (Class B) were asynchronously interviewed via email. They were asked similar questions to those used to test H4 and H6, as well as an open-ended question about whether effort and workload factored in to their decision to drop the course. Of the six students, one dropped during the second week purely based on course scheduling needs. This student did respond that their initial impression was of a high workload, but that they

were not part of the class long enough to provide an informed opinion. Thus, this student is not given any further consideration here.

Of the remaining five students, four responded with time estimations that fell above the third quartiles for the 'Readings' groups in Figure 6 and Figure 7, and these four students all responded with Likert ratings of 7 for all questions relating to effort and workload. The final student provided responses similar to the class averages. When asked whether workload and effort factored in to the decision to drop, this student mentioned scheduling and course prerequisites as the reason they left, and stated that, while somewhat high, they felt that the workload was manageable. In stark contrast, the other four students were fairly clear that workload was an important factor in their decision, if not in fact the main driver. Responses varied from a somewhat vague statement that workload was high and the student wanted to get a job, to condemnation of the teacher for unfair and unreasonable demands and expectations. Thus, it appears that the workload demands from flipping a class with mandatory pre-class readings played an important role in over 10% of the readings class dropping out.

CHAPTER SIX

DISCUSSION

There is a great deal of evidence from the literature that active classrooms result in significant gains in student learning (Prince, 2004), but to adopt such an approach in courses burdened by high expectations of content learning, it is necessary to implement strategies that free up class time. One currently popular method of accomplishing this is through “classroom flipping”, which forces students to engage in the initial transfer of knowledge outside of class, thus freeing up classroom time for teacher assisted homework style activities and group work (National Science Teachers Association, 2012). A key consideration with this approach, however, is to ensure that pre-class preparations do not constitute too heavy a workload (or at least the perception of such), as this has been demonstrated to force students into surface approaches to learning (Kember, 2004; Kember & Leung, 2006). To that end, the purpose of the present research was to compare the use of readings and teacher prepared vodcasts as two different methods of pre-class learning, to determine whether vodcasts could facilitate the initial construction of knowledge while easing students’ workload, and consequently result in improved student learning.

1. MEASURABLE LEARNING GAINS

The results of the study indicate that students did demonstrate measurable learning gains when provided with videos to view before class, but these were not as clear cut and ubiquitous as hypothesized. From the direct comparison of video and readings groups (units 1 and 2), it appears that students provided with videos attempted more and were more successful at completing low and high level questions on pre-class assignments (Figures 2 and 3, Table 4) but that the gains from these did

not carry forward into classroom assessments or, importantly, to summative unit tests (Figures 2, 3, and 4). These results might indicate that the true value of vodcasts lies in helping students initially prepare for class, but that flipped classroom activities have a tendency to even out any discrepancies in understanding, and ultimately that videos are no more useful than readings as a study tool to prepare for summative tests.

However, it's important to note that pre-class quizzes were meant to be completed individually (although some students indicated that this was not always the case), whereas answering clicker questions with assistance of other students was encouraged, and activities were always completed in groups. Thus, without discounting the beneficial effects of group learning (Bean, 1996), pre-class assessments may reflect the true value of vodcasts as compared to readings, in that scores on the in-class assessments could theoretically have been buoyed by strong students in each class, whereas the pre-class quizzes would reflect the actual level of understanding for each student. If this were the case, the expectation would be that a difference would emerge in the unit tests, as these were the most rigorous measures of individual ability. However, for units 1 and 2, no difference was observed between the groups.

Some clarification of the results from units 1 and 2 is provided by the direct comparison of both groups from units 3 and 4, when both classes had access to videos (Figure 5, Table 4). Here, Class B's average on pre-class assignments increased to match that from Class A, while the clicker and activity scores remained approximately equal. This would be the expected result if videos provided an advantage for pre-class preparation, but that group interactions in the class inflated overall scores based on the abilities of stronger students.

The truly interesting result from units 3 and 4, however, is the difference in performance on the unit tests; a difference also seen on the final exam. The

predictions of H3 and H3-A were that the videos group would score higher on the tests from units 1 and 2, but that both groups would have similar scores on the remainder of the summative assessments. Instead, the readings group scored the same as the videos group for units 1 and 2, but then significantly outperformed them on the units 3 and 4 tests and the final exam (Table 4). Thus, the observed change matches the predictions, in that the scores for the reading group improved when they were provided access to videos, but the absolute scores achieved by both groups are clearly not what were expected.

It's unclear whether this result actually provides support for the hypotheses. Certainly, the initial readings group seems to have shown some improvement when provided with videos, which lends strong credence to their value. However, the difficulty stems from explaining the poor performance on all of the summative assessments of the group provided with videos from the start. High school and college Science grades, as well as the pre-test administered on the first day of class, all suggest that the groups were of approximately equal strength from the outset (Table 1), and their performance on other measures during the first four units was similar. It's also highly unlikely that the discrepancy in scores came as a result of any fraudulent activity, as the unit tests were administered in back-to-back classes (providing barely enough time for the instructor to make it from one class to the next, let alone for students from one group to effectively convey answers to the other), and all students wrote the final at the same time. Thus, it seems like the videos group simply performed poorly on the tests.

One potential explanation for why this may have occurred stems from anecdotal observations made by the instructor over the semester, and from the instructor's overall experience with the two groups. Both groups had similar compositions in terms of the proportions of strong, average, and weak students, and in both classes about 10% of the group consisted of very vocal students, about 30% were willing to participate but were not particularly overbearing, another 40% of the

class were quiet and did not participate but were generally engaged, and the final 20% were completely disengaged (these estimations were made based on a review of the class lists and on the instructor's general perceptions of particular students; no explicit measurements of group dynamics or individual behaviour were taken during the semester). However, a key difference existed in terms of the types of students that were very vocal. In the videos group, these students were not particularly strong, and their contributions to the class, while typically on topic (or close to it), were often not very insightful and occasionally turned other students off or caused them to snicker. In stark contrast, the most vocal students in the readings group were amongst the strongest in the class, and their contributions and exchanges tended to be on a high level and very instructive, as they would talk through problems to find solutions in a way that included the entire class.

This important difference in group composition, as well as the difference in class size (Class A: 39 students, Class B: 33 students) ultimately had a substantial effect on the overall dynamics in each classroom, especially over the course of the semester. While the readings group evolved such that the classroom was usually fun and engaging, the videos group somewhat degenerated over the course of the semester, to the point where a higher proportion of students were disengaged on a class-by-class basis (again, these assertions are based on the instructor's impressions; no explicit measurements were collected during the semester to empirically demonstrate this development). The result was likely a very different experience in the course for students of the two groups, even when provided with exactly the same pedagogical approach.

These group dynamics could serve as an explanation for why students from the videos group performed so poorly. In theory, the pre-class quizzes would reflect the abilities and understanding of individual students, while the open and collaborative nature of in-class assessments would artificially buoy scores as strong students provided answers to weaker ones. However, the manner in which these

answers were provided could have made the difference, as students from the readings group would have witnessed the stronger students struggle with, and ultimately find solutions to, difficult problems posed in class, whereas students from the videos class would simply have heard the correct answer and entered it themselves or relied on the strong members of their group to complete activities for them. If this was indeed the case, the expectation would be of much greater learning gains from the more dynamic and engaging classroom (which is, after all, the goal of the flipped methodology), and this was clearly observed in the summative assessments.

2. STUDENT PERCEPTIONS

While results from the tabulated student scores somewhat deviated from expectations, results from the student survey and the asynchronous interviews were much more clear. Although students did not necessarily view videos as more effective preparatory and study tools than readings, they did find them to be more clear and easy to understand, as well as more fun and entertaining. Furthermore, the group with videos found them to be a crucial component of the flipped class methodology, while students from the readings group clearly felt that their experience in the course would improve considerably if they had access to videos (although this may simply seem like a case of wanting what you don't have, they were actually correct: their scores improved significantly, as compared to the video group, when they were allowed access to the vodcasts).

These results seem to be fairly reflective of broad student sentiments, as they are similar to numerous other reports from the literature on student perceptions of vodcasts. Students generally claim positive attitudes towards these, citing increases in recall, understanding, and overall motivation (Kay, 2012). Furthermore, similar to this study, Evans (2008) indicated that students found vodcasts more compelling and interesting than readings, but that they didn't necessarily find them to be more effective study tools than other instructor provided resources. Ultimately, then,

vodcasts in any context are recognized to have their limitations, but nonetheless appear to be broadly well received by students, most likely because of the relative novelty of this approach, as well as the convenience that videos offer and the fact that they are typically perceived as providing a path of lesser resistance.

This last perception is highlighted in the study through the responses examined under H7. Students from the readings group clearly had positive expectations of vodcasts, and believed their time demands would be eased if they had videos to watch. Interestingly, however, students from the videos group did not necessarily believe that watching videos would take less time than doing readings. This response could simply represent video students not fully appreciating what readings entail (i.e., taking videos for granted), and it would have been interesting to collect their perceptions to a similar question after switching them to readings, had this been done. However, video group students were also provided with the list of readings, so any students who felt compelled to do all the readings as well as watch the videos (there were some) certainly would not have indicated that videos required less time. Regardless, the response of video group students to this question was not expected, and somewhat obscures our understanding of whether students actually perceive an easing of time demands as a result of being provided videos to watch before class.

Fortunately, one of the key goals of this study was to actually try and quantify the amount of time that students were spending preparing for class, as well as to have students directly and unambiguously report on their perception of workload. Based on self-reported values, students from the readings group appear to have required more time to prepare for each class, and, consequently, spent more time in total preparing during each unit (Figure 6 and Figure 7). However, only one of the four specific hypothesis tests conducted for H4 returned a statistically significant value, which, in theory, makes drawing firm conclusions difficult. This statistical uncertainty is derived from the numerous outliers for each distribution (evident in

Figure 6 and Figure 7), which almost assuredly stem from the notoriously unreliable nature of student self-assessing (Clauss & Geedey, 2010; Darrow, Johnson, & Miller, 2002). These values were maintained in the distribution because SPSS did not identify them as 'extreme' outliers (these were eliminated), but a reasoned revision of Figure 6 and Figure 7 suggests that many of the data points are probably unrealistic: it seems doubtful that a student would spend 8 hours preparing for each class, or almost 40 hours for five classes over 2 ½ weeks. Instead, these numbers are most likely the result of students either misunderstanding the specific question they were being asked, feeling that their workload was too high and exaggerating to make a statement, or generally having an atrocious sense of time. Fortunately every distribution is beset with several of these unreasonable points which, while technically increasing the variation in each distribution and reducing statistical confidence, do make it possible to visually gloss over all of them and simply look at the underlying trends. Thus, even though the statistical results for these hypothesis tests are tentative, the general tendency seems sensible, and conforms to predictions: students required to do readings before class need to spend significantly more time preparing than students who are able to watch videos.

This assertion leads directly into H6, and provides a rationale to explain the result obtained, which is that students required to do readings perceive their effort levels and course workload to be higher than those who watch videos (Figure 8). Note that, strictly speaking, a perceived higher workload does not necessarily need to stem from actually spending more hours working, as abstracts like engagement and motivation are actually more crucial determinants of workload perception than discrete variables like time (Kember, 2004). Still, the fact that readings do appear to require more time, combined with student reports that watching videos is more fun and entertaining, all provide a solid underpinning to explain why students doing readings perceived their course workload to be greater, and, ultimately, might help explain the result obtained from testing H5, where students from the readings group were less likely to actually complete their pre-class work (Table 5).

This is one of the key findings from this study, because, even on its own, it provides an impetus for creating and using videos to flip a class. Evidence from the literature suggests that high workload demands often lead students to adopt surface learning approaches, and can consistently be correlated with poor learning outcomes (Giles, 2009; Lizzio, Wilson, & Simons, 2002), especially if they lead to students being less likely to complete their work, as was evidenced here. Further, they can lead to disengagement, apathy, or, as evidenced in this study, class abandonment: Four students, or over 10% of the class enrollment, dropped out of the readings section for reasons directly related to their perception of a burdensome and prohibitive workload. Certainly, this type of result should be a clear indication that a particular pedagogical strategy needs to be reconsidered, and suggests that providing mandatory assigned readings before every flipped class may be asking too much of the students. Of course, it must be noted that the general flipped classroom methodology is demanding (of both teachers and students), and that students watching videos before class were still required to do a great deal of work. However, as noted in Kember and Leung (2006), it is possible to successfully place relatively high workload demands on students, as long as they find the work interesting and the environment stimulating; it appears, based on the results for H6, that providing vodcasts for students within a flipped class approach might help satisfy this requirement.

CHAPTER SEVEN

CONCLUSION

This study has reached a number of conclusions that will be of interest to post-secondary educators with an interest attempting or adopting a flipped class methodology for their courses. Before presenting these and their implications, however, along with potential avenues for future research, it is important to thoroughly explore the limitations of this study, such that the reader can interpret the findings presented here appropriately.

1. LIMITATIONS

Most of the basic limitations of this study were outlined in Chapter Four. The study sample was fairly small, somewhat limiting statistical power, and certainly at least raising questions about external validity. Further substantiating these questions is the fact that the sample group represented a Science department in a college that is more ethnically diverse and has lower overall entrance scores than similar colleges in the surrounding area, and that the colleges in general are an educational construct found only in the province of Quebec (CEGEPs). Thus, while the results of the study are certainly interesting, and offer fairly strong evidence that, in a flipped classroom context, providing videos to view before class instead of readings can have positive effects on students' time demands, perception of workload, and overall learning outcomes, the factors mentioned above must be weighed carefully by the reader when giving consideration to how this study might apply to their particular classroom context.

Two other important limitations arose or became clear over the course of study. The first of these was the necessity of providing both groups of students with

videos during units 3 and 4. While the decision to do this was made based on ethical concerns, predominantly due to the fact that an inordinately high percentage of students dropped out of the readings class, continuing with the initial quasi experimental design (i.e., alternating both groups between readings and videos) would have provided a more rigorous comparison between the two learning strategies. Instead, the result of adapting the study design was to impose limitations on the ability of this research to ascertain the differing effects of readings and videos. For one, it only made it possible to assess the effect of switching methods using one class. More importantly, however, it prevented the administering of a second survey at the end of units 3 and 4, as the surveys that were initially prepared were no longer valid, and time constraints precluded the design of new ones. The consequence of these limitations appears to be all of the somewhat unclear results from this study:

1. It would have been important to determine whether the video groups' performance on summative assessments actually got worse if they only had readings, as this would have provided a key contrast to the improvement noted in the initial readings group on the tests from units 3 and 4. The changes there could then have been compared to the outcome on the final exam when both groups had access to videos, to identify whether the initial video group improved again;
2. The uncertainty associated with the amount of time students were spending preparing for class stemmed from unrealistic outlier values self-reported by certain students. However, if students recognized that they were spending less time with the videos and were asked to provide time estimates on a second survey, even outlier points would have reflected this trend;
3. The response provided by video students which indicated their belief that videos did not take less time than readings could have been contrasted against a similar question after removing their access to videos, to determine whether their perceptions remained the same or if they ended up identifying a temporal benefit to using videos.

Thus, while the results of the study do provide reasonable evidence for the benefits of videos, this likely could have been stronger if the original study design was maintained through to the end of the semester.

The second important limitation to the effectiveness of the study and veracity of the results was not anticipated, as it does not often appear to be mentioned in published studies similar to the one described here. This, despite the fact that the possibility of this potential problem existing should theoretically be fairly ubiquitous in any study of this nature, and there is even an entire subset of the educational (and psychological) field devoted to its exploration. At issue here is the potential for variation to exist in classroom dynamics (or group dynamics; Schmuck & Schmuck, 2001), and it manifested in this study as a difference in classroom climate between the two groups. As previously mentioned, the groups were statistically equivalent from a demographic and pre-course aptitude perspective, and were deliberately provided with the exact same class experience, save for the differing video/reading pre-class resources during the first two units. However, despite these fundamental quasi-experimental controls, the instructor's impressions were that the classroom climate ended up differing substantially between the two groups as the semester progressed for reasons beyond the variables considered in this study. This difference itself then essentially became a hidden variable in the experiment, as it was not assessed in any way and was therefore not controlled for or incorporated into the analysis, but is nonetheless speculated to have influenced the observed results by potentially contributing to the poor summative assessment scores of the videos group (see section 1. from this chapter). Indeed, classroom climate and group dynamics have previously been shown to affect student performance, albeit predominantly in the social sciences (Carlson, et al., 2006; Evans & Dion, 1991; Gascoigne, 2012; Gully, Devine, & Whitney, 1995; Mullen & Cooper, 1994; Phillips, 1992; Prisbell, Dwyer, Carlson, Bingham, & Cruz, 2009), so it certainly seems possible that student group interactions could have been a confounding factor here as well.

The identification of a potentially important lurking variable typically weakens the possible conclusions and inferences that can be made based on the results of an experiment, and this case is no exception. While the evidence collected and presented here seems to point fairly strongly to the somewhat intuitive conclusion that providing videos before a flipped class would be more beneficial for students than just providing readings, it remains that many of these results could theoretically be explained by differing group dynamics and classroom learning experiences. This limitation must be given strong consideration by the reader when weighing the conclusions presented here, and in fact provides a strong impetus for myriad future studies.

2. IMPLICATIONS AND FUTURE STUDY

Regardless of any uncertainty caused by the identification of an uncontrolled variable, it remains that the results of this study should have a number of fairly clear implications. First, and most obviously, it appears that any time and effort on the part of a flipped classroom college instructor to prepare, amass, or organize videos as pre-class instructional tools would likely be time well spent. As compared to assigned readings as the alternative option, providing videos for students to watch seems likely to lower their time demands, reduce their perception of workload, and potentially increase their learning gains, at least as these are measured through test scores. Since the latter is a key goal of college instruction, and the first two are very probably large components in achieving this, it would appear clear that any time invested in attempting to implement this pedagogical approach would be warranted.

Another potential implication arising from these results relates to assigned readings in general. The Introductory Biology course examined in this research incorporates an above average amount of content knowledge, and thus admittedly requires more readings than classes from many other subjects. Despite this fact, the results from the readings group indicating how much time they spent preparing for

class and how high they perceived their workload to be should give pause to any instructor who assigns readings to their students. While there is a clear understanding that college students should undertake a fairly substantial workload, there is also the reality that today's students have greater responsibilities and more demands on their time than students from any previous generations (Hall, 2010; Hanson, Drumheller, Mallard, McKee, & Schlegel, 2011). Thus, as instructors, we must tread carefully in an attempt to balance the need for courses to be challenging and stimulating with the imposition of overly high workload demands. The indication from this study was clearly that students perceived that readings required a great deal of time; for any instructor employing mandatory assigned readings in their pedagogical approach, the results of this study should give them cause to reassess their methodology.

Finally, a last somewhat ancillary, and yet potentially very important implication to emerge from this study is that measures of classroom climate should be incorporated as controls into any study of this nature. This does not appear to be common practice in educational research, and yet studies of group dynamics, and the results of this study, would suggest that classroom climate could be as important a factor to measure and control for in a quasi-experimental setup as incoming student scholastic aptitudes (Schmuck & Schmuck, 2001). A particular instrument called the Connected Classroom Climate Inventory (Dwyer, et al., 2004) has been used with success in the past to assess classroom climate, albeit within design settings specifically assessing the effects of this variable (Carlson, et al., 2006; Prisbell, Dwyer, Carlson, Bingham, & Cruz, 2009). The indication from this research would be that an instrument of this nature should be incorporated into any experimental or quasi-experimental design that involves comparing two or more interacting groups of students, as classroom climate has the potential to play a key role in any outcomes.

In fact, this is actually a fairly interesting recommendation to the field for future research. While the study of group dynamics has firmly identified these as important for student learning, no studies identified by the author have incorporated a

measure of classroom climate as a control into research designs meant to examine other variables. Doing so could be very interesting, as it would be fascinating to identify how this might function as a covariate or interactive term with other more traditional demographic, aptitude, or student reported elements, and even to eventually determine whether student group interactions have played hidden roles in driving observed results from other studies.

Of course, another suggestion for future research is to replicate the design described herein, or, rather, the initial study design of alternating sections between videos and readings, in order to cross-validate the findings and address the limitations of this study. If practical or feasible, such studies would ideally involve true experimental designs, and should also incorporate measures of classroom climate, as well as methods to validate student reported usage of videos.

Finally, an interesting question for future research stems from the videos themselves. The bulk of the videos employed in this study were from YouTube and were produced by a teacher in Montana using a webcam to record his face as he reviewed some well designed PowerPoint slides. However, other videos were publisher-produced animations, and the author created several slightly more animation heavy videos as well. On the opposite end of the spectrum, numerous studies reviewed in Chapter Three provided simple lecture captures as the vodcasts for students. Given the seemingly large disparity in vodcast style and quality, as well as the doubtless greater time and effort required to create higher quality vodcasts, a natural question emerges as to whether any endeavour to produce higher quality videos would translate into improved student outcomes. Walker et al. (2011) began the process of answering this question, but their study was conducted in a traditional lecture-based classroom, where it could be argued that the videos were not the primary source of information for the students. Furthermore, their study only examined lecture captures versus prepared PowerPoint videos, and thus did not incorporate a range of potential vodcast options. If one is to accept the premise that a

flipped classroom methodology has the potential to improve student learning, and that providing videos to view before class is a more effective approach at getting students to engage in the initial transfer of knowledge, it then becomes incumbent upon us to identify the best and most effective way to produce and provide these videos to students, in order meet our obligation as college instructors and provide our students with the best learning experience possible.

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APPENDIX A

STUDENT SURVEY PROVIDED TO VIDEO GROUP

General Biology I Instructional Strategy Survey

This survey is part of a study currently being conducted between within General Biology 1 classes to compare the effectiveness of different instructional strategies, one of which you encountered over the first two units of this course. With this survey we are seeking your honest opinions and truthful responses, so please answer every question honestly and to the best of your ability. Your responses will remain completely anonymous, so please **do not include your name anywhere on this survey.**

Complete this survey at home and return it to your instructor at the beginning of your next class. If you do this your name will be entered into a raffle to win a prize worth \$100 (more on what this prize will be below). Note that you are not obliged to complete the survey, but, if you choose not to, you will not be eligible to win. Your instructor will note on a list that you submitted the survey at the beginning of class, but will not identify individual surveys by name.

The exact prize for the raffle has yet to be determined. In fact, the prize will be decided based on suggestions you and your fellow student make here. On the three lines below, list three items that you think would make good prizes, in your order of preference. If your prize selection consists of multiple prizes which total \$100 (for example two gift cards of \$50), place these all on one line. The top 5 prize suggestions will be compiled and presented for voting using clickers in class, at which point the exact prize (or prizes will be decided). Subsequent to this the winner (or winners) will be notified.

Prize Suggestions:

1. _____
2. _____
3. _____

Survey:

Demographics

1. For each of the questions below, circle the option that applies. If circling 'Other', please provide a response in the space provided:

- i. Gender: Male Female
- ii. Program: Health Pure and Applied Other: _____
- iii. Semester of Study in CÉGEP: 2 3 4 5 6 Other: _____

APPENDIX B

DEMOGRAPHIC QUESTIONNAIRE AND CONSENT FORM

CONSENT TO PARTICIPATE IN RESEARCH

Vodcasts versus readings: Assessing the effect of using videos to facilitate the initial transfer of knowledge

You are asked to consent to participate in a research study conducted by Karl Laroche, Edward Awad, Stephanie Felkai, and Terry Saropoulous from the Biology Department at Vanier College.

If you have any questions or concerns about the research, please feel free to contact your particular teacher either in person or via email, using the contact information provided in your course outline.

PURPOSE OF THE STUDY

The research will seek to determine the instructional benefits of 'flipping' classes by having students view lecture videos before class and then do online mini assignments, as compared to flipping classes where students are assigned readings before class.

PROCEDURES

We are requesting your consent to include in our study your grades to date in the class and any demographic information you provide here.

POTENTIAL RISKS AND DISCOMFORTS

The only potential risk is that one method may result in greater learning outcomes than the other. If this is the case, and you are currently in the group demonstrating less learning gains, your instructor may choose to switch you to the alternate method over the course of the semester.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

This research hopes to identify the benefit of using videos to flip classes, and could help direct pedagogical development at Vanier and other institutions in the future.

CONFIDENTIALITY

Every effort will be made to ensure confidentiality of any identifying information that is obtained in connection with this study. Your data will be provided to the principal researcher (KL) who will conduct the relevant analyses. Once completed, any information obtained beyond regular grades (stored in Omnivox) will be deleted.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. In particular, you may exercise the option of not including your data in the study, or of withdrawing your information at any point. You may also refuse to answer any questions you don't want to answer from the questionnaire and still remain in the study.

RIGHTS OF RESEARCH PARTICIPANTS

You can choose to not provide your consent or discontinue your participation at any time and without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. This study has been reviewed and received clearance through the Vanier College Research Ethics Board. If you have questions regarding your rights as a research participant, contact:

Ginny Laboni
 Student Services, Room C-203C
 Vanier College, 821 Ste. Croix,
 Montréal, Québec, H4L 3X9
 (514) 744-7500 ext. 7104
 labonig@vaniercollege.qc.ca

SIGNATURE OF RESEARCH PARTICIPANT

I have read the information provided for the study “Vodcasts versus readings: Assessing the effect of using videos to facilitate the initial transfer of knowledge” as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

Note: You must be of majority age in the province of Quebec (18 years) to participate in this survey.

Name of Participant (please print)

Signature of Participant

Date

DEMOGRAPHIC INFORMATION

Your group's grades and questionnaire responses will be compared to the results from other groups who were presented with a slightly different instructional approach. In order to validate this comparison, it will be necessary to statistically control for various student characteristics inherent in each group. This will also be required to assess the external validity of the results, i.e., to determine whether the results from this study can be used to make inferences regarding groups from other CEGEPs.

To that effect, we request that you provide us with the following demographic information for control purposes. **Any data you provide here will be used exclusively for the purposes of this research, and every possible effort will be made to ensure that your information remains completely confidential. Further, any information you provide below WILL NOT have any bearing on your standing within this course.** Your data will be provided to the principal researcher (KL), and will be destroyed immediately once all relevant analyses have been completed. We thank you very much in advance for your cooperation.

Name: _____ Age: _____

Gender: Male Female Primary Language (Mother Tongue): _____

With what ethnicity do you most closely identify? _____

Program of Study: _____ Semester of Study: _____

Overall average from last year of high school: _____

Science specific average from last year of high school: _____

Cumulative average to this point at Vanier: _____

Science specific average to this point at Vanier: _____

If you do not know the answers to the last four questions, these data can be obtained from the Vanier registrar. For this, however, we need to obtain your written consent. You can choose not to provide your consent for this and continue to remain in this study without consequence.

I have read the information provided above and in the research consent form, and agree to allow the principle research (KL) to obtain both my high school and Vanier overall and science specific averages from the registrar.

APPENDIX C

ETHICAL CLEARANCE CERTIFICATE



November 24, 2012

Karl Laroche
Biology Department
Vanier College

Dear Karl,

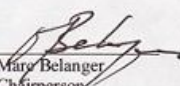
The Vanier College Research Ethics Board has evaluated your research request entitled: Vodcasts vs Readings: Assessing the effect of using videos to facilitate the initial transfer of knowledge.

Attached is a conditional certification based on the following required updates:

- It is recommended that the participants be of majority age (18+) to avoid parental consent. If this is not possible then parental consent as well as student consent will have to be obtained. Consent form must be in both French and English.
- Demographic data collection must be included on consent form.
- Wording changes on consent form (as attached).
- Delete any reference to offering grade points for participation in research. No extra grades may be given as incentive (page 6 of Research Proposal).
- Comparison ratings should read; Less Effective-As Effective- More Effective (all questions).

Please make all the necessary changes and remit to the Research Ethics Board (Nora Boyadjian, E-118).

Regards,



Marie Belanger
Chairperson
Research Ethics Board

c.c. REB members, Caroline Hanrahan
encl.
nb



CONSENT TO PARTICIPATE IN RESEARCH

Vodcasts versus readings: Assessing the effect of using videos to facilitate the initial transfer of knowledge

You are asked to consent to participate in a research study conducted by Karl Laroche, Edward Awad, Stephanie Felkai, and Terry Saropoulous from the Biology Department at Vanier College.

If you have any questions or concerns about the research, please feel free to contact your particular teacher either in person or via email, using the contact information provided in your course outline.

PURPOSE OF THE STUDY

The research will seek to determine the instructional benefits of 'flipping' classes by having students view lecture videos before class and then do online mini assignments, as compared to flipping classes where students are assigned readings before class.

PROCEDURES

~~You have been taking part in this study since the beginning of the semester. All we are requesting now is your consent to include your performance in the class to date within the overall data sample for the study. We are requesting your consent to include your grades, to date, in the class for the study and the questionnaire.~~

POTENTIAL RISKS AND DISCOMFORTS

The only potential risk is that one method may result in greater learning outcomes than the other. If this is the case, and you are currently in the group demonstrating less learning gains, your instructor may choose to switch you to the alternate method over the course of the semester.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

This research hopes to identify the benefit of using videos to flip classes, and could help direct pedagogical development at Vanier and other institutions in the future.

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PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. In particular, you may exercise the option of not including your data in the study, or of withdrawing your information at any point. You may also refuse to answer any questions you don't want to answer from the questionnaire and still remain in the study. ~~The investigator may withdraw you from this research if circumstances arise that warrant doing so.~~

RIGHTS OF RESEARCH PARTICIPANTS

You can choose to not provide your consent or discontinue your participation at any time and without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. This study has been reviewed and received clearance through the Vanier College Research Ethics Board. If you have questions regarding your rights as a research participant, contact:

Ginny Iaboni
Student Services

VANIER
CÉGEP / COLLEGE

Vanier College, 821 Ste. Croix, Montreal, Quebec, H4L 3X9
C-203C / (514) 744-7500 ext. 7104
iabonig@vaniercollege.qc.ca

SIGNATURE OF RESEARCH PARTICIPANT/LEGAL REPRESENTATIVE

I have read the information provided for the study "Vodcasts versus readings: Assessing the effect of using videos to facilitate the initial transfer of knowledge" as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

~~(Note: If you are not of majority age in the province of Quebec (18 yrs), a legal guardian or representative must sign this consent form as well).~~

Note: You must be of majority age in the province of Quebec (18 years) to participate in this survey.

Name of Participant (please print)

Name of Legal Representative (if applicable)

Signature of Participant or Legal Representative

Date

APPENDIX D

PRE-CLASS QUIZZES, IN-CLASS CLICKER QUESTIONS, IN-CLASS ACTIVITY, AND UNIT TEST 1

Low-Level Pre-Class Moodle Quiz Questions from Class 1

The Miller-Urey experiment showed that in any environment with conditions similar to those of early Earth:

- a. inorganic molecules would react to form organic molecules.
- b. organic molecules would form primitive cells.
- c. an oxygen atmosphere would develop.
- d. RNA would self-replicate.

Which of the following is not an example of an energy transformation?

- a. The electrical energy flowing through a light bulb's filament is converted into light and heat.
- b. A shoe drops, converting potential energy to kinetic energy.
- c. A chemical reaction converts the energy in sunlight into the chemical energy in formaldehyde.
- d. Sunlight strikes a prism and separates into distinct wavelengths.

Which of the following statements about water is CORRECT?

- a. Compared to most liquids, the evaporation of water requires a large amount of heat.
- b. Compared to most other substances, the temperature of water rises when it absorbs heat.
- c. Water is more dense at 100C than it is at 37C.
- d. Water is a good solvent for lipids.

A solution with a pH of 3 has how many more H⁺ than a solution with a pH of 6?

- a. 10 times
- b. 200 times
- c. 1000 times
- d. 100 times

What do cohesion, surface tension, and adhesion have in common (with reference to water)?

- a. All are produced by covalent bonding.
- b. All increase when temperature increases.
- c. All have to do with nonpolar covalent bonds.
- d. All are properties related to hydrogen bonding.

Why does ice float in liquid water?

- a. The hydrogen bonds between the molecules in ice prevent ice from sinking.
- b. Ice always has air bubbles that keep it afloat.
- c. The crystalline lattice of ice causes it to be denser than liquid water.
- d. Hydrogen bonds keep the molecules of ice farther apart than in liquid water.

What determines if a molecule is polar, nonpolar, or ionic?

- a. The differences in the electronegativities of the atoms
- b. The number of protons
- c. The distance of the electrons from the nucleus
- d. The ionic charges

Low-Level In-Class Clicker Quiz Questions from Class 1

Which of the following is an example of a hydrogen bond?

- A. the bond between C and H in methane (CH_4)
- B. the bond between the H of one water molecule and the O of another water molecule
- C. the bond between Na and Cl in salt
- D. the bond between two hydrogen atoms
- E. the bond between Mg and Cl in MgCl_2

When the atoms involved in a covalent bond have the same electronegativity, what type of bond results?

- A. A double bond
- B. A hydrogen bond
- C. A nonpolar covalent bond
- D. A polar covalent bond

What term describes any substance that dissociates to form H^+ ions when it is dissolved in water?

- A. acid
- B. base
- C. isotope
- D. molecule

Which of the following characteristics does *not* apply to water?

- A. All three atoms in water readily form hydrogen bonds with other molecules.
- B. The covalent bonds in water are highly polarized.
- C. The water molecule readily forms hydrophobic interactions.
- D. The water molecule is asymmetric.

Oil and water don't mix because

- A. the surface tension of the oil is not great enough
- B. oil molecules are too cohesive
- C. hydrogen bonds will not allow the interaction
water does not dissolve nonpolar substances

High-Level Pre-Class Moodle Quiz Questions from Class 1

Why is acetic acid (look it up) a weak acid?

- a. Because it doesn't dissolve well in water
- b. Because it has a higher pH than HCl
- c. None of the choices presented as answers for this question are correct.
- d. Because H doesn't dissociate easily from the highly electronegative O

Why were reduced compounds such as H₂, CH₄, and NH₃ required for chemical evolution to get started?

- a. They could act as electron acceptors in redox reactions.
- b. They could act as electron donors in redox reactions.
- c. They contain the atoms most likely to be found in living organisms.
- d. They all have polar covalent bonds.

In chemical evolution, following the formation of reduced C compounds, the addition of heat allowed _____ bonds to form.

- a. H to O
- b. C to H
- c. C to C
- d. C to O

High-Level In-Class Clicker Quiz Questions from Class 1

Which of the following phenomena does *not* involve hydrogen bonding?

- A. Insects walking on the surface of lake water
- B. Ice cubes floating in a glass of water
- C. Clouds of water vapor supported by an air mass
- D. Dew drops on a plant

To act as an effective coolant in a car's radiator, a substance has to be a liquid at the temperatures found in your car's engine and have the capacity to absorb a great deal of heat. You have a reference book with tables listing the physical properties of many liquids. In choosing a coolant for your car, which table would you check first?

- A. pH
- B. density at room temperature
- C. heat of vaporization
- D. specific heat

Which of these 3 molecules has more potential energy?

- A. Histidine
- B. Glucose
- C. Lauric acid
- D. Histidine and lauric acid possess about the same amount of potential energy.

What does it mean to say that a molecule such as H_2 or CH_4 is reduced?

- A. It is small in size.
- B. It is likely to form free radicals when struck by sunlight.
- C. It is likely to act as an electron acceptor in redox reactions.
- D. It has relatively high potential energy.

Which of the following best summarizes the essence of chemical evolution?

- A. Energy in the form of sunlight and heat was transformed into chemical energy.
- B. Instead of being radiated back to space, energy in the form of sunlight and heat was retained in the oceans and atmosphere.
- C. Entropy increased.
- D. An increasing number of exothermic reactions occurred.

In-Class Activity Questions from Class 1

Class 1: Chemistry of Life

101-NYA

Group Members:

Part A: 10 minutes

1. For each of the following phenomena explain how they are based on and related to the properties of water (1 point each).
 - a. During winter, air temperatures in Canada can remain below 0°C for months; however, the fish and other animals living in the lakes survive.

 - b. Many substances, such as NaCl and sucrose, dissolve quickly in water.

 - c. Sweating and the evaporation of sweat from the body surface help reduce a human's body temperature.

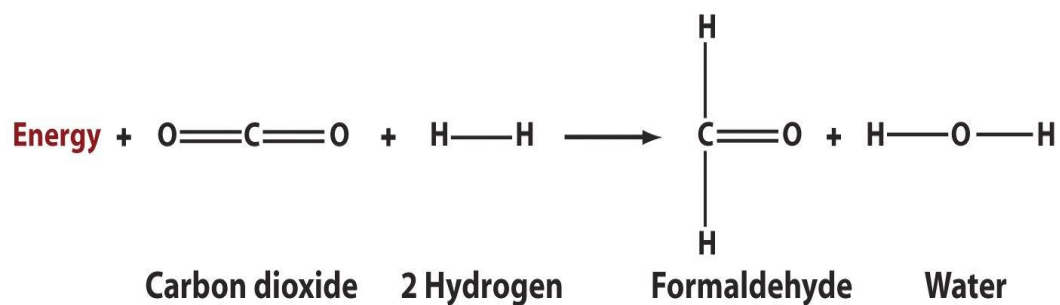
 - d. Water drops that fall on your car tend to bead or round up more after you polish (or wax) the car than before you polished it.

 - e. If you touch the edge of a paper towel to a drop of colored water, the water will move up into (or be absorbed by) the towel.

Class 1: Chemistry of Life

101-NYA

Group Members:



Part C: 15 minutes

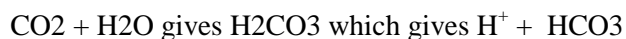
1. Add dots to each covalent bond in the figure to show the relative positions of the electrons involved (4 points).
2. Does the carbon atom in this reaction get reduced or oxidized (1 point)?
3. Label the reactant molecules that act as the electron donor and the electron acceptor (1 point).
4. What is producing heat that is radiating out from your body at this moment (2 points)?

Phenol Red Demonstration Instructions:

Demonstration: Prepare a solution of 0.02 M sodium bicarbonate/carbonate buffer, pH 9.5, with a few drops of phenolphthalein (that has been dissolved in methanol to 10 mg/ml), to make it a rich pink color. Depending on the size of the class and lecture room, mix 5 ml of it in a 15 ml conical tube, or 15 ml in a 50 ml Erlenmeyer flask. During class, a straw (hollow coffee stirrers work well) is offered to a student volunteer, who must then blow gently into the flask or tube for 15 to 60 seconds, until it becomes clear. [*Note to Instructor:* Be sure to test this in advance to make sure it works—you can correct long blowing times by diluting the buffer if need be.]

- Is there a volunteer to help out?
- Instructions: blow gently through the straw into the pink solution for 15-30 seconds.
- What happens?
- What does the “indicator” tell you?
- Why did it happen?

Answer: The solution went from pink to clear, indicating a *decrease* in pH (the color-changing dye is phenolphthalein), i.e., an *increase* of acidity.

• WHAT COULD THIS BE DUE TO?

GENERAL BIOLOGY I
UNIT TEST I

Winter 2013

Version A

VALUE: 5%

DURATION: 80 MINUTES

NAME: _____

PART A

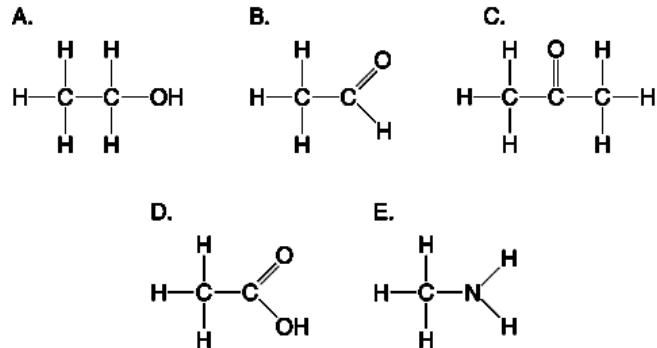
MULTIPLE CHOICE QUESTIONS (1 pt each)

- 1) Domain Eukarya includes
 - A. Protists
 - B. Plants
 - C. Fungi
 - D. Animals
 - E. All of the above

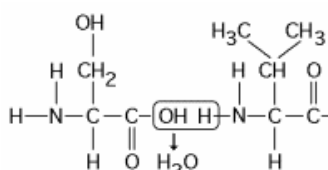
- 2) Which of the following types of cells utilize deoxyribonucleic acid (DNA) as their genetic material?
 - A. Plant
 - B. Animal
 - C. Archaea
 - D. A and B only
 - E. A, B, and C

- 3) Which molecule is an alcohol?

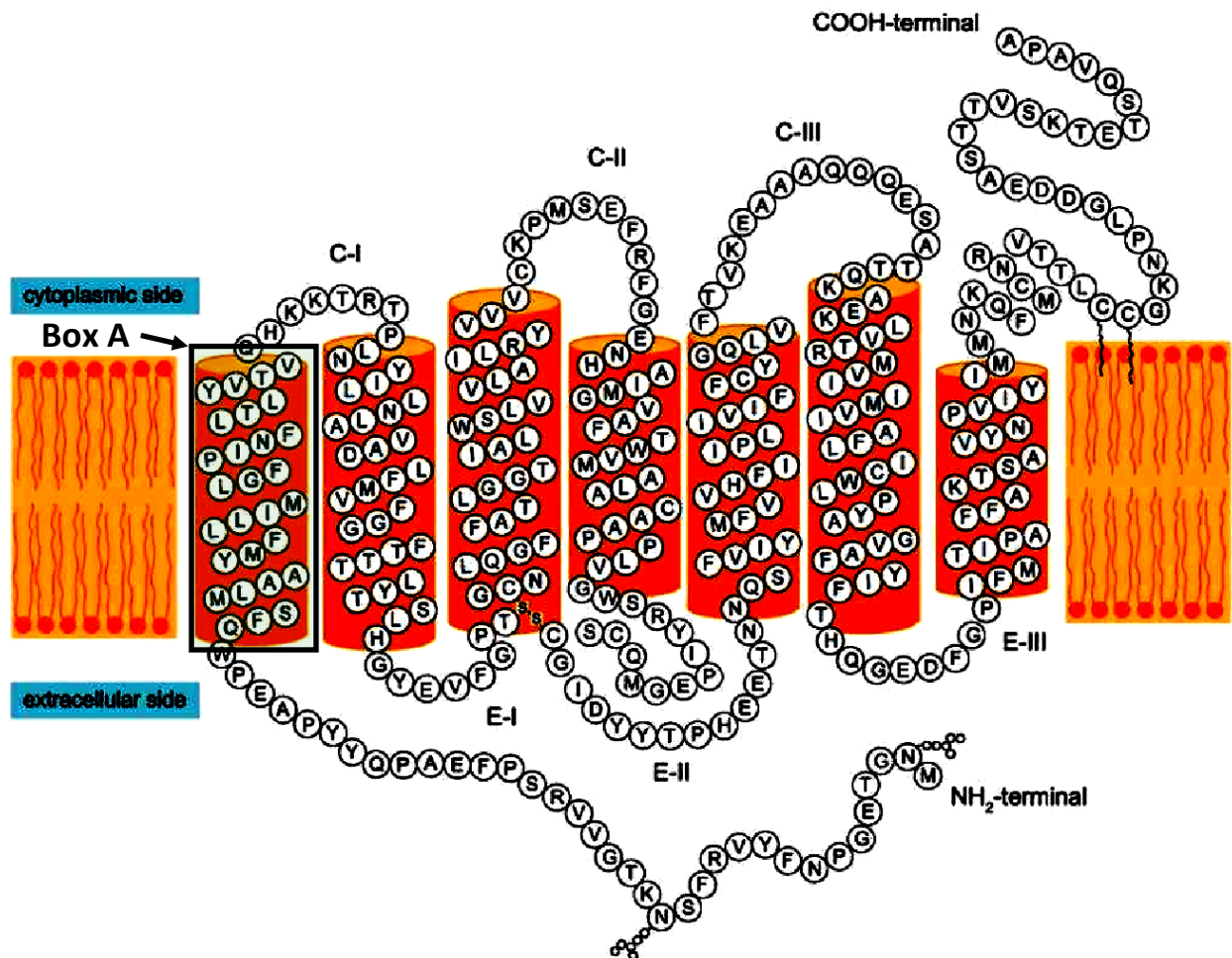
- A. A
- B. B
- C. C
- D. D
- E. E



- 4) While taking a walk in the rain you notice that water drops that fall on leaves tend to form rounded drops or beads. Which of the following is responsible for this phenomenon?
 - A. Water molecules on in droplets are high in kinetic energy.
 - B. Water molecules are cohesive and form hydrogen bonds with each other.
 - C. Water has a high specific heat.
 - D. Water has a high heat of vaporization.
 - E. Water's greatest density occurs at 4°C

- 1) If you wanted to use a radioactive or fluorescent tag to label only the RNA in a cell and not the DNA, what compound(s) could you label that is/are specific for RNA?
- Thymine only
 - Phosphate only
 - Ribose only
 - Uracil only
 - Both C and D are correct
- 2) The chemical reaction illustrated in the figure results in the formation of a
- hydrolysis reaction
 - peptide bond
 - glycosidic linkage
 - phosphodiester linkage
- 
- 3) Lipids form the barriers surrounding various compartments within an organism. Which property of lipids makes them a good barrier?
- Many biologically important molecules are not soluble in lipids.
 - Lipids are polymers.
 - Lipids store energy.
 - Triglycerides are lipids.
 - Lipids release large amounts of energy when broken down.
- 4) Why do endurance athletes practice "carbohydrate loading", meaning to eat massive amounts of starch, in the days leading up to a long race?
- Starch provides dietary fiber or "roughage" that aids digestion.
 - Starch is used as a building block for the synthesis of many other molecules.
 - Carbohydrates are reduced molecules that can provide the chemical energy required during exercise.
 - Starch can be used to synthesize cellulose and build up the cell walls of muscles.
- 5) What describes the primary structure of a nucleic acid?
- The sequence of bases
 - The sequence of amino acids
 - The double helix
 - The hairpin loop
- 6) Cellulose, the structural component of plant cell walls, is the most abundant organic compound on Earth. Which of the following is a feature that cellulose and another molecule called chitin have in common?
- β -1,4-glycosidic linkages
 - peptide bonds between adjacent strands
 - covalent bonds between adjacent strands
 - α -1,4-glycosidic linkages
- 7) What would be an **unexpected** consequence of changing one amino acid in a long protein chain?
- The tertiary structure of the protein might be changed.
 - The primary structure of the protein would be changed.
 - The biological activity or function of the protein might be altered.
 - Only A and C are correct.
 - A, B, and C are correct.

Use the image below to answer questions 12 and 13



- 1) An analysis was performed on the protein rhodopsin, which is a light-sensitive protein found in species ranging from archaea to humans. The structure (schematically shown above, where each letter represents an amino acid) is characterized by a single polypeptide chain with seven α -helical segments (the cylinders in the image) that loop back and forth across a phospholipid bilayer membrane. Thus, rhodopsin is what is known as a **transmembrane protein**. Based on the image of the molecule produced from this analysis (above), and using your understanding of the properties of phospholipid bilayers, what kind of amino acid is 'L' most likely to be?

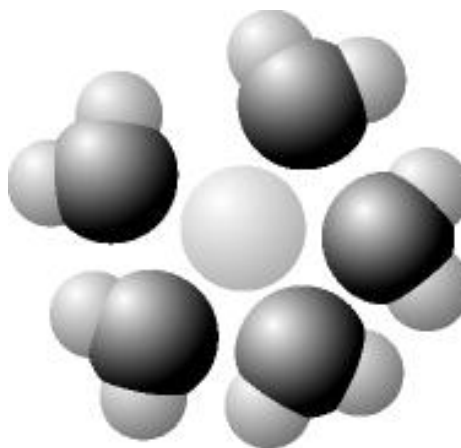
 - A. Non-polar
 - B. Polar
 - C. Charged
 - D. Not enough information is provided to answer this question.
- 2) Highlighted area 'Box A' includes what levels of protein structure?

 - A. primary
 - B. secondary
 - C. tertiary
 - D. A and B
 - E. A, B, and C

1) Nakano reported in the journal *Science* in February 2000 that “An RNA enzyme (ribozyme) from the hepatitis delta virus can catalyze self-cleavage of... [one of its chemical]... bonds.” This reaction is inherently slow due to the formation of an unfavorable negative charge on the ribozyme. The author goes on to show that this self-cleavage is made faster by joining it with an acid-base reaction that neutralizes the negative charge. Nakano’s model describes a positively charged cytosine base on the ribozyme acting as the acid, and magnesium hydroxide acting as the base. Specifically, the cytosine donates its proton (H^+) to neutralize the unstable negative charge that would have formed on the ribozyme.

How does Nakano’s quote provide support for the claim that RNA is a good candidate as the first life form?

- A. It demonstrates that RNA would be able to maintain stability within a basic environment by donating protons, which would be required for the first life form to subsist within the alkaline environment on early earth.
- B. It demonstrates that RNA can serve as an informational template, which would allow the first living molecule to self-replicate.
- C. It demonstrates a mechanism by which RNA can act as a self-catalyst, which would be required for the first living molecule to be able to copy itself.
- D. It demonstrates that magnesium hydroxide was present on early earth, which is a product of RNA self-copying.
- E. It does not provide support for the claim that RNA was the first life-form.



- 2) The image above displays a hydration shell. The molecule in the center is most likely to be
- A. Na^+
 - B. Cl^-
 - C. H^+
 - D. OH^-
 - E. polar

PART B
SHORT ANSWER QUESTIONS

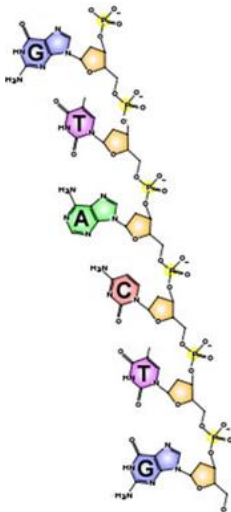
- 1) Sandy is given 4 samples and told they are lysine (an amino acid), lactose (the sugar in milk), insulin (a protein hormone), and RNA. The samples are in test tubes marked 1, 2, 3 and 4, but Sandy doesn't know which compound is in which tube. She is instructed to identify the contents of each tube.
- In her first test, she tries to hydrolyze a portion of the contents of each tube. Hydrolysis occurs in all tubes, except tube 3.
 - In Sandy's next test, she finds that tubes 1, 2, and 3 are positive for nitrogen, but only tube 2 gives a positive result when tested for the presence of sulfur.
 - The last test Sandy performs shows that the compound in tube 1 contains a high percentage of phosphate.

Which tube contains RNA? Explain. **(2 pts)**

Which one contains Lysine? Explain. **(2 pts)**

- 2) The current best hypothesis for how the first macromolecules of life were formed depends on the assumption that the atmosphere on early earth was devoid of O_2 gas. Why is this assumption so important? **(2 pts)**

3)



The image to the left displays a small strand of DNA which will serve as the template for making a small RNA segment. What will be the nucleotide sequence of the RNA molecule produced? In your answer be sure to identify the 5' and 3' end of your segment. **(1 pt)**

Your answer above should have made use of the nucleotide base pairing rules. What properties of the nucleotides (and in particular the nitrogenous bases) establish these rules? In other words, why will one nucleotide only bond with another particular nucleotide? In your answer, include a description of the types of bonds involved in base pairing. **(3 pts)**

The DNA strand in the image above, along with the complementary strand that is bonded to it (not pictured), are treated with an enzyme that cleaves any phosphodiester linkages between T and A. What would the resulting double-stranded DNA segments be (make sure to indicate the directionality of all resulting DNA strands)? **(2 pts)**

1) Look at the structure of the amino acids leucine and asparagine. Which one is more likely to interact with water (**1 pt**), and why (**1 pt**)? How would the other amino acid interact to establish tertiary (3°) folding (**1 pt**)?

2) Complete this table by putting check marks in the appropriate boxes. Note that more than one box can be checked per row (i.e., more than one answer per question), but also that a row might not have any checks (i.e., no correct answers for that question). In this case, a correct mark will be awarded for leaving the row blank. (**5 pts**)

	$ \begin{array}{c} \text{HO}-\text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{N} \\ / \quad \backslash \\ \text{H} \quad \quad \text{H} \end{array} $	$ \begin{array}{c} \text{HO}-\text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array} $	$ \begin{array}{c} \text{H}-\text{C}=\text{O} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{HO}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array} $
Which of these are monomers?			
Which of these can be part of a polymer that displays 4° structure?			
Which of these molecules contain(s) reduced carbon bonds that are regularly used for energy storage?			
Which of the molecules above act(s) as building blocks of biological membranes?			
Which molecules form components of nucleotides?			
Which of the molecules can form β glycosidic linkages?			
Which molecules could be joined together to form a highly hydrophobic oligopeptide?			

PART 3
SHORT ESSAY

In what ways are all species on Earth alike biochemically? Why? Identify some (at least 3) ways in which species may differ from one another biochemically. Explain. **(5 pts)**

APPENDIX E

PARAMETRIC ASSUMPTIONS

Table 6

Tests of Parametric Assumptions for Data Used to Test H1, H2, H3, and H3-A

Measure	Hypothesis	Group	Skewness	Kurtosis	Shapiro-Wilk W (sig.)	Levene's Test F (sig.)
Moodle	H1 Units 1 and 2	Videos	-0.85	0.84	0.950 (.105)	2.358 (.130)
		Readings	0.01	-0.72	0.971 (.575)	
	H2 Units 1 and 2	Videos	-1.10	2.57	0.929 (.023)	0.077 (.783)
		Readings	0.06	1.40	0.960 (.304)	
	H3-A Units 1 and 2	Videos	-0.58	-0.03	0.951 (.116)	0.005 (.944)
		Readings	-1.34	3.30	0.905 (.011)	
	H3-A Units 3 and 4	Videos	-0.29	-0.19	0.978 (.672)	0.199 (.657)
		Readings	-2.54	8.80	0.764 (.000)	
Clickers	H1 Units 1 and 2	Videos	-1.62	3.22	0.857 (.000)	5.174 (.026)
		Readings	-0.04	0.57	0.964 (.387)	
	H2 Units 1 and 2	Videos	-1.10	1.89	0.898 (.003)	1.107 (.297)
		Readings	-0.42	-0.63	0.949 (.159)	
	H3-A Units 1 and 2	Videos	-1.12	1.15	0.902 (.004)	6.536 (.013)
		Readings	0.36	0.35	0.967 (.454)	
	H3-A Units 3 and 4	Videos	-0.92	1.54	0.928 (.022)	2.819 (.098)
		Readings	-0.18	0.10	0.984 (.910)	
Activities	H2 Units 1 and 2	Videos	-1.82	4.03	0.785 (.000)	16.089 (.000)
		Readings	0.19	-1.16	0.927 (.042)	
	H3-A Units 3 and 4	Videos	-1.61	2.41	0.812 (.000)	3.003 (.088)
		Readings	-1.54	2.68	0.843 (.000)	
Tests	H3 Units 1 and 2	Videos	-0.29	-0.18	0.982 (.822)	2.130 (.149)
		Readings	-0.33	-0.58	0.967 (.466)	
	H3 Units 3 and 4	Videos	0.36	-0.36	0.962 (.242)	0.137 (.712)
		Readings	-0.07	-0.39	0.971 (.565)	
	H3 Final	Videos	-1.57	4.50	0.892 (.002)	3.362 (.071)
		Readings	-0.15	-0.65	0.976 (.714)	

Videos Group (Class A) N = 36, Readings Group (Class B) N = 30

Highlighted boxes indicate rejection of the null hypothesis (alpha = 0.05)

Table 7

Tests of Parametric Assumptions for Normalized Data Used to Test H1, H2, H3, and H3-A

Measure	Hypothesis	Group	Skewness	Kurtosis	Shapiro-Wilk W (sig.)	Levene's Test F (sig.)
Moodle	H1 Units 1 and 2	Videos	-0.28	-0.71	0.967 (.522)	0.895 (.348)
		Readings	-0.15	-0.55	0.973 (.737)	
	H2 Units 1 and 2	Videos	-0.02	-1.11	0.952 (.244)	0.845 (.362)
		Readings	-0.19	1.55	0.953 (.322)	
	H3-A Units 1 and 2	Videos	-0.21	-0.86	0.946 (.174)	0.047 (.829)
		Readings	-0.34	-0.71	0.957 (.374)	
	H3-A Units 3 and 4	Videos	0.00	-0.76	0.974 (.711)	1.117 (.295)
		Readings	-0.76	0.58	0.947 (.233)	
	H3-A Comparison	Videos	-0.38	-0.86	0.952 (.164)	0.323 (.572)
		Readings	0.29	0.23	0.989 (.994)	
Clickers	H1 Units 1 and 2	Videos	-0.82	1.24	0.943 (.141)	0.438 (.511)
		Readings	-0.02	1.25	0.955 (.341)	
	H2 Units 1 and 2	Videos	0.73	1.12	0.921 (.056)	1.816 (.183)
		Readings	-0.43	-0.84	0.939 (.159)	
	H3-A Units 1 and 2	Videos	0.12	-1.12	0.931 (.074)	1.301 (.259)
		Readings	0.54	0.79	0.954 (.333)	
	H3-A Units 3 and 4	Videos	0.41	-0.56	0.958 (.325)	1.625 (.208)
		Readings	0.31	-0.73	0.952 (.301)	
	H3-A Comparison	Videos	0.27	-0.90	0.965 (.428)	0.672 (.416)
		Readings	0.18	0.24	0.961 (.356)	
Activities	H2 Units 1 and 2	Videos	-1.00	-0.10	0.918 (.052)	1.754 (.103)
		Readings	0.36	-1.11	0.917 (.051)	
	H3-A Units 3 and 4	Videos	-1.47	2.88	0.926 (.063)	1.464 (.231)
		Readings	-0.62	0.20	0.920 (.059)	
	H3-A Comparison	Videos	0.13	-0.34	0.949 (.174)	5.993 (.018)
		Readings	-0.62	1.19	0.938 (.090)	
Tests	H3-A Comparison	Videos	0.15	-0.11	0.991 (.987)	6.805 (.012)
		Readings	0.18	-0.30	0.980 (.823)	

Videos Group (Class A) N = 32, Readings Group (Class B) N = 24

Highlighted boxes indicate rejection of the null hypothesis ($\alpha = 0.05$)

Table 8

Tests of Parametric Assumptions for Data Used to Test H4

Measure	Unit	Shapiro-Wilk <i>W</i> (sig.)
Time per class	unit 1	0.847 (< 0.0001)
	unit 2	0.372 (< 0.0001)
Time per unit	unit 1	0.682 (< 0.0001)
	unit 2	0.630 (< 0.0001)

Table 9

Tests of Parametric Assumptions for Data Used to Test H4

Extreme Outliers Were Removed From Data Set

Measure	Unit	Shapiro-Wilk <i>W</i> (sig.)
Time per class	unit 1	0.879 (< .0001)
	unit 2	0.918 (.0012)
Time per unit	unit 1	0.939 (.0001)
	unit 2	0.861 (< .0001)

Table 10

Tests of Parametric Assumptions for Data Used to Test H6

Measure	Unit	Shapiro-Wilk <i>W</i> (sig.)
Prep Effort	unit 1	0.902 (< .0001)
	unit 2	0.944 (.0011)
Workload	unit 1	0.905 (< .0001)
	unit 2	0.896 (< .0001)