May 2014

The Effects of Supplemental Online Learning Aids on Student Performance and Student Engagement in Medical Microbiology

Kimberly Murray
University of Wisconsin-Milwaukee

THE EFFECTS OF SUPPLEMENTAL ONLINE LEARNING AIDS ON STUDENT PERFORMANCE AND STUDENT ENGAGEMENT IN MEDICAL MICROBIOLOGY

by

Kimberly Murray

A Thesis Submitted in

Partial Fulfillment of the

Requirements for the degree of

Masters of Science

in Biomedical Sciences

at

The University of Wisconsin-Milwaukee

May 2014

ABSTRACT

THE EFFECTS OF SUPPLEMENTAL ONLINE LEARNING AIDS ON STUDENT PERFORMANCE AND STUDENT ENGAGEMENT IN MEDICAL MICROBIOLOGY

by

Kimberly Murray

The University of Wisconsin-Milwaukee, 2014
Under the Supervision of Jeri-Anne Lyons, PhD

The purpose of this study was to determine the effects of online learning aids on student performance and engagement. The thirty-five participants of the current study were students enrolled in two sections of a junior level Medical Microbiology laboratory. The experimental section was required to spend ten minutes each week on an online learning aid. The online program, StudyMate™, was used to present text and images in the form of flash cards, multiple choice questions, matching, and crossword puzzles. Both groups completed the Index of Learning Style survey, an initial engagement survey at the start of the course, and a final engagement survey at the end of the course. Statistical analysis showed no significant differences between the groups at the start of the course or after the course was completed for learning style, science grade point average, overall grade point average, initial engagement or final engagement. A moderate correlation was found between microbiology course and laboratory grades and a reflective learning style.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter One

General Introduction

Educational institutions face new challenges with each passing year. An emphasis on education has led to an influx of new students with varying ages, life and career experiences, and educational backgrounds. Regardless of these differences, more students have adopted the view that higher education is a commodity. With this new view, significant pressure is placed on institutions to account for effective measures of education and student learning. As a result, institutions of higher education are placing increased emphasis on improving student outcomes, such as retention, persistence, and completion. One factor central to positive student outcomes relates the energy devoted by the student to the academic experience, referred to as ***student engagement***. Kazmi defines student engagement by how involved a student is with his or her learning, more specifically the “amount of physical and psychological energy that the student devotes to the academic experience” (Kazmi, 2010). Axelson and Flick (2011) add to this definition of student engagement to include the attitudes and feelings students develop toward peers, professors, and the institution that produce a sense of affiliation and belonging. Since student engagement is a key component to student success, an important question to be addressed is what steps institutions of higher education can take to increase student engagement to ensure student success. This study investigates the effects of additional online educational aids on student performance and engagement.

Hypothesis

The objective of this study is to determine the effects of providing additional educational engagement opportunities for students in a junior level clinical microbiology course on the final course grade. The main vehicle for these additional aids is the online study aid program, StudyMate. It is hypothesized that providing engaging educational aids will result in higher student performance in Medical Microbiology lab and lecture.

The hypothesis and objective of this study will be addressed by the following specific aims:

1. Determine the learning style of the control and experimental group of students.
2. Develop and implement engaging educational aids in the experimental group.
3. Compare student performance in each group to determine the effects of additional learning aids.

The results of this study provided insight into these research questions

1. Are there significant differences between the experimental and control groups *before* the implementation of the StudyMate lessons?
2. Are there significant differences between the experimental and control groups *after* the implementation of the StudyMate lessons?
3. How did the implementation of the StudyMate lessons affect student engagement?
4. Will student overall grade point average or science grade point average predict Medical Microbiology grades?

Significance of the Study

Through the analysis of student performance and engagement, this study addresses the growing need for a quantitative investigation of how web-based instruction influences performance and engagement. Although research of web-based instruction has flourished in recent years, published contributions are limited to topics such as student perception of web-based instruction, instructor management of web resources in an online learning environment, and social interaction in online learning environments. This study addresses the gap in quantitative analysis of student performance and engagement in web-based learning. Valuable time is spent by instructors and students on web-based course work; therefore, it is imperative to determine the effectiveness of web-based learning. The implications of this study will aid in future course development in Medical Microbiology.

Factors Governing Student Success

Three important constructs are commonly associated with positive student outcomes: integration, involvement, and engagement. These concepts are often intertwined but still have unique attributes. Integration is defined as the relationship between the student and the institution (Wolf-Wendel, Ward, & Kinzie, 2009). It is the extent to which the student develops the same attitudes and beliefs of the faculty and students within his or her institutional environment (Palloff & Pratt, 2007) (Wolf-Wendel et al., 2009). Student integration reflects the relationships formed by students with peers, faculty, and staff. The students' perception of how well they fit with the

institutions' community and the students' willingness to participate in formal and informal academic experiences lead to academic integration (Wolf-Wendel et al., 2009).

Another important factor of student success is the level of involvement a student develops in his or her academic career. Student involvement is defined as the amount of energy, both physical and psychological, that a student applies to his or her academic experience (Wolf-Wendel et al., 2009). It may seem as though involvement is related to the number of activities a student participates in; however, the depth of the involvement is used as the indicator of student success (Svanum & Bigatti, 2009) (Wolf-Wendel et al., 2009). The depth of involvement is associated with the time and effort spent on a particular activity. A student who is in only one organization and actively involved with the organization will have a higher success rate than a student who is a member of 3 organizations but does not actively participate in them (Wolf-Wendel et al., 2009). It is important to emphasize that a balance between the two is crucial; participation to either extreme has a negative impact on student retention (Kazmi, 2010).

The third component commonly associated with student performance is student engagement, which represents a unique arrangement between the student and the institution. Student engagement is multidimensional and includes aspects of academic, social, and institutional engagement. According to Wolf-Wendel et al. there are two key components to student engagement: 1) the amount of time and effort a student spends on his or her studies and extracurricular involvement; and 2) how the educational institution designates its resources to providing learning and service opportunities for

the students (Wolf-Wendel et al., 2009). Institutions of higher education are responsible for creating and maintaining an environment conducive to student engagement. The present study focuses on the level of student engagement and success in a junior level medical microbiology class.

Graduation rates and proficiency test results are easily measured and analyzed. This type of data does not provide information on student engagement indicators such as interaction with peers and faculty or the students' overall experience at a particular institution. Student engagement has been shown to be a positive predictor of learning and personal development. Studies have shown that students who are involved in "effective educational practices," defined below, are not only more likely to perform better in his or her course work, but also complete his or her degree. An engaged student is more likely to persist and complete his or her education (Svanum & Bigatti, 2009). Both academic and social involvement has been linked to academic success (Wolf-Wendel et al., 2009).

Assessment of Student Engagement

The National Survey of Student Engagement (NSSE), administered by the University of North Carolina system, was specifically designed to assess the extent to which students are engaged in "good educational practices" and "what they gain from his or her college experiences" (NSSE, 2011). NSSE reports on 5 **benchmarks** of effective educational practices:

1. **Level of Academic Challenge**- Challenging intellectual and creative work is central to student learning and collegiate quality. Colleges and universities promote high levels of student achievement by emphasizing the importance of academic effort and setting high expectations for student performance. Item questions included in the survey inquire about time spent preparing for class, number of assigned readings, and number of assigned written papers.
2. **Active and Collaborative Learning**- Students learn more when they are intensely involved in his or her education and asked to think about what they are learning in different settings. Collaborating with others in solving problems or mastering difficult material prepares students for the messy, unscripted problems they will encounter daily, both during and after college. Item questions included in the survey inquire about contribution to class discussions, presentation preparation, and working with other students outside of class to complete an assignment.
3. **Student-Faculty Interaction**- Students learn firsthand how experts think about and solve practical problems by interacting with faculty members inside and outside the classroom. As a result, his or her teachers become role models, mentors, and guides for continuous, life-long learning. Item questions included in the survey inquire about faculty interaction in the form of discussion concerning course grades and career aspirations as well as time spent with faculty completing research or student life activities.
4. **Enriching Educational Experiences**- Complementary learning opportunities enhance academic programs. Diverse experiences teach students valuable things

about themselves and others. Technology facilitates collaboration between peers and instructors. Internships, community service, and senior capstone courses provide opportunities to integrate and apply knowledge. Item questions included in the survey inquire about participation in community service work, student discussions of differing values, and the use of technology to discuss or complete coursework.

5. **Supportive Campus Environment**- Students perform better and are more satisfied at colleges and universities that are committed to his or her success and cultivate positive working and social relations among different groups on campus. Item questions included in the survey inquire about support generated by the campus environment to succeed academically, work, family, and relationships with other students, faculty and the campus as a whole.

In 2011, 751 four-year colleges and universities participated in the NSSE survey, including the University of Wisconsin-Milwaukee (UWM) (National Survey of Student Engagement, 2011). The University of Wisconsin-Milwaukee Office of Assessment and Institutional Research identified two groups of institutions to compare engagement bench marks. The Urban Consortium consisted of 14 university selected peer institutions including institutions such as the University of Missouri-St. Louis, Southern Illinois University-Edwardsville, and Roosevelt University. The second peer group included 49 research universities (high research activity) Carnegie Classification including Kent University, New Mexico State University, and Western Michigan State. UWM students identified as first year (n=4,617) or senior level (n=5,346) students were

asked via e-mail to participate in the NSSE survey. A total of 1,911 (19%) students completed the survey, 769 first year students and 1,142 senior level students. UWM overall completion rate was slightly less than the Urban Consortium as well as the research university group, 24% and 23% completion rates respectively.

Select data from the NSSE 2011 Survey are shown in Tables 1 and 2. Responses from senior students from UWM, the Urban Consortium, and the Carnegie Universities show several significant findings. The Carnegie Universities and the Urban Consortium students had significantly more faculty-student interaction as shown by working with faculty on research projects and faculty-student discussions when compared to UWM students. UWM seniors also spent significantly less time each week on extracurricular activities such as student organizations, student government, intercollegiate or intramural sports than both groups.

Table 1. NSSE 2011 Academic and Intellectual Experiences Analysis
Senior Level University Student Responses
In your experience at your institution during the current school year, about how often have you done each of the following? 1=Never, 2=Sometimes, 3=Often, 4=Very often

	UWM	Urban Consortium	Carnegie Universities
Worked with other students on a project outside of class	2.59	2.64	2.81***
Asked questions or contributed to class discussion	2.97	3.08***	3.05**
Come to class without completing assignments	2.13	2.07*	2.11
Revised a paper two or more times before handing the assignment in	2.39	2.50***	2.45
Worked with a faculty member on a research project	1.56	1.66***	1.80***
Discussed grades or assignments with an instructor	2.61	2.77***	2.80***
Discussed career plans with a faculty member	2.19	2.25*	2.36***

One, two, or three asterisks, referring to three significance levels ($p<.05$, $p< .01$, and $p<.001$) compared to UWM Seniors.

Table 2. NSSE 2011 Time Usage Analysis

Senior Level University Student Responses
About how many hours do you spend in a typical 7-day week doing each of the following? 1=0 hrs/wk, 2=1-5 hrs/wk, 3=6-10 hrs/wk, 4=11-15 hrs/wk, 5=16-20 hrs/wk, 6=21-25 hrs/wk, 7=26-30 hrs/wk, 8=More than 30 hrs/wk

	UWM	Urban Universities	Carnegie Universities
Preparing for class	4.31	4.22	4.37
Work on campus	1.96	1.64***	1.92
Work off campus	4.15	4.26	3.34***
Commuting	2.47	2.58***	2.43
Relaxing	3.54	3.37**	3.51
Caring for a dependent	2.35	2.96***	2.34
Extracurricular activities	1.62	1.71*	2.12***

One, two, or three asterisks, referring to three significance levels ($p<.05$, $p< .01$, and $p<.001$) compared to UWM Seniors.

Student Engagement and Academic Performance

A study completed by Carini, Kuh, and Klein (2008) compared student engagement and academic performance. 1,058 students from 14 colleges and universities completed the National Survey of Student Engagement(NSSE) along with the RAND (Research and Development) exam and the general Graduate Record exam (GRE). This study showed that distinct “effective educational practices” produced different effects dependent upon the students’ academic year (Carini et al., 2006). For example, senior students’ academic performance benefited more from working with other students and faculty members than first year students (Carini et al., 2006). On the other hand, first year students had a greater benefit by being prepared for class and writing several drafts of papers than senior students (Carini et al., 2006). Furthermore, this study demonstrated the greatest benefit of student engagement was for those

students who came to institutions with an educational disadvantage, reflected by low SAT scores (Carini et al., 2006).

To determine if student engagement correlated with degree completion and student performance, Svanum and Bigatti administered an author-designed, self-reported assessment of student engagement to 56 male and 169 female undergraduate students enrolled in upper division abnormal psychology course (Svanum & Bigatti, 2009). Factors assessed included going to class, completing reading assignments, studying notes and studying in groups. Based on a median of the data, the authors divided the students into those characterized as demonstrating a high level of course engagement vs. those with a low level of course engagement. Quantitative indicators of student success, including college admission scores, G.P.A., semester grades and time to degree completion, were obtained from the university records (Svanum & Bigatti, 2009). The study demonstrated that college admission exam scores, traditionally used to predict student success, did not correlate with degree completion and were independent of the level of student engagement [$r(169)=0.02$, $p=0.81$]. Rather, high student engagement correlated with an increased G.P.A [$F(1,98)=21.6$, $p<0.01$; $R2=0.15$], and decreased time to degree completion,[$r(138)=-0.27$, $p<0.01$, 95%CI $r=-0.42$ to -0.11], and that these students were 1.5 times more likely to graduate from college than a less engaged student [OR=1.5, 95%CI=1.1 to 2.0]. (Svanum & Bigatti, 2009). Furthermore, the authors found that a large portion of academic course engagement was dependent on a skill-effort component, such as going to class, completing reading assignments, and studying notes (Svanum & Bigatti, 2009).

Web-based and Computer Assisted Instruction

With the accessibility of the internet, web-based instruction is emerging as a commonly utilized mode of delivering course materials. The flexibility of web-based instruction is attractive to students and institutions alike. Not only have institutions placed an emphasis on entirely online courses and degrees but also blended courses that incorporate web-based components into face-to-face courses and degree programs. These types of course components require the student to designate time outside of class to complete his or her course work. Web-based course components are accessible when a student wishes, and learning is self-paced, placing greater responsibility on the student for his or her own learning (Means, Toyama, Murphy, Bakia, & Jones, 2010)

While the online environment offers increased exposure to diverse course content in a variety of formats, studies show that the success of students and instructors in online courses is affected by his or her personality, and student and instructor performance in a face-to-face classroom does not necessarily equate to his or her performance in an online learning environment. Students and instructors who have extroverted personalities often struggle to create his or her own presence in online learning environments (Palloff & Pratt, 2007). There individuals rely heavily on face-to-face interactions and body language as cues for communication (Palloff & Pratt, 2007). The online learning environment often relies entirely on written communication, removing a key component to the success of the extroverted personality. On the other

hand, introverted personality types often have an easier time establishing his or her presence in an online learning environment than in a face-to-face classroom (Palloff & Pratt, 2007). Students and instructors that suffer from performance anxiety may be more comfortable online (Palloff & Pratt, 2007). The pressure of immediate response and thought is removed. The online format offers time to reflect before responding.

The challenges associated with on-line learning can be curtailed by providing a blended course format (Schuhmann & Skopek, 2009). If performed and utilized effectively, a blended course can provide an invaluable opportunity for student engagement. The blended format, combining online and face-to-face course work, shifts the focus from a passive learning format in the form of lectures to an active learning format (Vaughan, 2007). The online technologies can be used to present case studies, tutorials, simulations, and self-testing (Vaughan, 2007). The face-to-face meetings can then be utilized to discuss material in person to further understanding (Vaughan, 2007). The face-to-face time can be spent on more challenging material rather than the presentation of basic facts and concepts (Vaughan, 2007).

Blended courses also provide additional advantages for university administration, faculty, and students. From an administration standpoint blended courses can expand education offerings while reducing the costs associated with offering face-to-face courses (Vaughan, 2007). Meeting face-to-face requires space, utility use, and custodial personnel to be included in budgeting for each course offering (Vaughan, 2007). An efficient schedule could allow for several blended courses to be

taught for the same operating costs as one face-to-face course (Vaughan, 2007). Blended courses also offer multifaceted student-teacher interactions ranging from e-mail and discussion boards to face-to-face conversations (Vaughan, 2007).

Student Performance and Web-based Instruction

A comparison of traditional face-to-face learning and blended courses in an exercise physiology course showed that students in a blended course performed 9.9% higher or one letter grade higher than the traditional face-to-face exercise physiology students (McFarlin, 2008). The face-to-face section of the course meets two times a week for 1.5 hours each meeting. The first meeting consisted of general introductory material and the second was composed of advanced exercise physiology material. The blended format met once for 1.5 hours each week for the advanced material. The introductory material in a visual and verbal format was posted on an online learning management system. As stated by the author, "the key objective of the online component was to provide students the opportunity to prepare for in-class lectures by watching online lectures in a self-paced format" (McFarlin, 2008). The unrestricted access to course materials permitted enhanced levels of interaction and made the student responsible for his or her own learning. Students enrolled in the blended course were required to take an online quiz after completing the online lecture (McFarlin, 2008). In an effort to enhance the traditional lecture, McFarlin utilized an in-class response system for the blended course face-to-face meeting. Both formats received the same course material; the blended format received the material in a

technology rich format which resulted in a statistically significant higher final grade, $p<0.05$ (McFarlin, 2008).

Researchers at the University of Southern Mississippi surveyed undergraduate anatomy and physiology lab students and instructors to determine which subject matter was the most difficult to learn and teach (Gopal, et al., 2010). A majority of the instructors and students identified the cardiovascular system as the most difficult to teach and learn (Gopal, et al., 2010). Gopal et al. developed a password protected website that incorporated engaging tools such as “Spelling Bee, Pronunciation Corner,” and an interactive diagram tool to practice anatomy and physiology terms. The website also had a “Teachers Resource” area that allowed instructors to customize the set of terms as well as adding his or her own audio files if necessary. This study consisted of 85 students in the control group and 80 in the experimental group. Analysis of the first lab exam showed a significant difference between mean scores for the two groups $t(163)=2.218$, $p=0.028$(two-tailed). This analysis showed that for the first exam containing no cardiovascular content, the control group performed better than the experimental group. Analysis of the cardiovascular portion of the second exam indicated a significant difference between mean scores of the two groups $F(1,158)=23.134$, $p<0.001$, $\omega=0.20$ (Gopal, et al., 2010). In this case, the control group had a lower mean ($M=30.66$) than the experimental group ($M=38.59$), indicating that the website helped the experimental groups perform better on the cardiovascular portion of the second exam (Gopal, et al., 2010). In fact, analysis of the non-cardiovascular portion of the second exam showed that the control group preformed

significantly better than the experimental group, $F(1,158)=6.314$, $p<0.001$, $\omega=0.1$ (Gopal, et al., 2010).

Another study carried out by Allen, Walls, and Reilly examined 9 years of anatomy instruction involving 856 students to determine the effect of web-based interactive instruction on exam performance (Allen, Walls, & Reilly, 2008). Research designers converted the peripheral nervous system content of the course to online tutorials that incorporated interactive tools such as patient cases, review games, simulated interactive patients, flashcards, and quizzes that provided immediate feedback (Allen et al., 2008). The multi-tool approach was designed to address diverse learning styles. An analysis of variance for the peripheral nervous system exam questions yielded a significant difference, indicating that students who had been exposed to the online tutorials answered a larger portion of the questions correctly than those students with no exposure $F(2,237)=4.63$, $p<0.05$ (Allen et al., 2008). Not only did student performance improve but surveyed students also “reported favorably on all interactive learning objects” $F(4,1051)=30.01$, $p<0.001$ (Allen et al., 2008). The authors concluded that considering the “improvement in the peripheral nervous system content exam scores and the favorable student perception…it is reasonable to suggest that these interactive techniques would be beneficial if incorporated into other components of human gross anatomy” (Allen et al., 2008).

A meta-analysis conducted by the U.S. Department of Education revealed several important positive attributes of web-based instruction that contributed to student

success (Means, Toyama, Murphy, Bakia, & Jones, 2010). Analysts screened approximately 1,200 studies conducted between 1996 through July 2008 to find those that:

1. Contrasted a web-based instruction to a face-to-face learning environment
2. Measured student learning outcomes
3. Used a rigorous research design
4. Provided adequate information to calculate effect size.

Forty-three of the fifty studies that fit these strict criteria were college level studies. Student outcomes were defined as exam scores, assignment scores and discussion scores (Means et al., 2010). A rigorous research design included only those studies with random assignment or controlled quasi experimental designs (Means, Toyama, Murphy, Bakia, & Jones, 2010). A comparison of online instruction versus traditional face-to-face instruction demonstrated a significant improvement in student performance in online courses (effect size +0.20, $p<0.001$) (Means et al., 2010). Courses combining online and face-to-face elements demonstrated a significant advantage relative to purely face-to-face instruction than purely online (Means et al., 2010). The mean effect size for the studies included in the meta-analysis comparing blended with face-to-face instruction was +0.35, $p<0.001$, while mean effect size comparing online to face-to-face was +0.05, $p=0.46$ (Means et al., 2010). The meta-analysis also demonstrated that online learning is an effective learning format for undergraduate (effect size +0.30, $p<0.001$) and for graduate students (effect size +0.10, $p<0.001$)

(Means et al., 2010). The higher performance was in part attributed to online learners spending more time on tasks than traditional face-to-face learners (Means et al., 2010). The meta-analysis did not account for curriculum material, pedagogy or learning time, the perceived advantage of online learning may reflect these differences rather than the difference is course platform (Means et al., 2010). However, the conclusion that students perform better in blended courses may reflect that online courses promote more time being spent on learning than online or face-to-face course platforms (Means et al., 2010).

Learning Styles

Learning is the acquisition of knowledge or skill through study, practice, and training (Dictionary.com, 2012). The benchmark definition of learning styles is the "characteristic cognitive, effective and psychological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment" (Romanell, Bird, & Ryan, 2009). In other words, an individual’s learning style is defined by the *preferences* of how the learner perceives, interacts with, and responds to the format in which information is provided (Romanell et al., 2009). These preferences vary from person to person. Awareness of different learning style preference can produce a diverse learning environment. For example, instructors can incorporate components that appeal to all students. Students on the other hand can modify information to fit his or her specific learning style to increase his or her academic achievement (Romanell et al., 2009).

Assessment of Learning Styles

A variety of instruments have been developed to determine learning styles. Each instrument classifies learning styles in a unique way, leading to ambiguity in the field. Here, the three most common instruments will be discussed.

The oldest method of evaluating learning style describe here is the VARK Framework method (Tanner & Allen, 2004). This method describes four sensory modes of learning: visual, auditory, reading/writing, and kinesthetic. The four categories are summarized in Table 3.

Table 3. VARK Framework Learning styles

LEARNING STYLE	DESCRIPTION
Visual	Learn through seeing, prefer drawings and pictures
Auditory	Learn through hearing, prefer listening to lectures and discussion
Reading/Writing	Learn through interaction with textual materials
Kinesthetic	Learn through touching, prefer experiments that emphasize doing

Students whose preference is defined as visual by the VARK Framework method prefer to learn information that is presented in the form of maps, diagrams, charts and graphs (Fleming & Mills, 1992). The information must be presented in a manner to be more than text in boxes; information presented as symbols and diagrams depicting a relationship between the information would be easily understood by a visual learner (Fleming & Mills, 1992).

The second learning style defined by the VARK model is the aural or auditory preference, identifying students who learn best by speaking or hearing information.

These students will often say things or ask obvious questions that have already been answered (Fleming & Mills, 1992). Aural learners learn by talking through material, by speaking out loud or to oneself. Learning environments that appeal to these students are lectures, group discussions, radio, web-chat and e-mail. E-mail may not be an obvious choice for aural/auditory learning but e-mail often appears in conversational style with non-formal language and slang that directly appeals to an aural learner (Fleming & Mills, 1992).

At the college level, teaching and learning are most often presented in the third VARK learning preference, reading and writing (Fleming & Mills, 1992). This modality emphasizes text-based input and output. Students and instructors who prefer this learning style are often inclined to use PowerPoint, lists, dictionaries, and quotations to learn. Reading and writing in all forms especially manuals, reports and essays appeal to students with a reading and writing preference (Fleming & Mills, 1992).

The final modality within the VARK model is the kinesthetic learning style. Kinesthetic students prefer the use of experience and practice, whether it is simulated or real situations, to learn new material (Fleming & Mills, 1992). The experience and practices must have a correlation to a real situation for kinesthetic learners to grasp the information. Demonstrations, videos, and movies of real events as well as case studies appeal to kinesthetic learners. Kinesthetic learners learn from the experience of activity and preforming new material that has been presented (Fleming & Mills, 1992).

The VARK model has been updated in recent years to include students who do not have a strong standard preference but demonstrated a multimodal learning style. Two types of multimodal styles have been defined. The first type of learner has the ability to switch from mode to mode with ease and chose a single mode to fit the specific context of information (Fleming & Mills, 1992). These learners show almost equal preference for 2 or 3 specific styles. A second type of multimodal learner gathers information to fit into each of his or her preferred styles. These learners may appear like procrastinators but in fact they often have a better grasp of understanding than others because of the time spent converting information to all his or her preferred styles (Fleming & Mills, 1992).

Another widely accepted method used to evaluate learning styles is Howard Gardner's Theory of Multiple Intelligences. The traditional definition of intelligence assumes that intelligence is a measureable construct (Merriam, Caffarella, & Baumgartner, 2007). Gardner proposes an alternative vision; a pluralistic view of the mind, recognizing many different and discrete facets of intelligence (Gardner, 1983). The Theory of Multiple Intelligences is founded on the concept that human intelligence must entail a set of skills for problem solving; these skills enable the individual to resolve problems and difficulties that are encountered to produce an effective end product (Gardner, 1983). Gardner defines eight *Criteria of an Intelligence.*

1. The potential isolation by brain injury-Can a particular faculty be destroyed or spared as a result of a brain injury?

2. The existence of idiot savants, prodigies and other exceptional individuals-Are there individuals who exhibit highly uneven abilities or deficits?
3. An identifiable core operation or set of operations-Do one or more processing operations or mechanisms exist for specific kinds of input? An example would be an individual's sensitivity to pitch.
4. A distinctive developmental history, along with a definable set of expert "end-state" performances-Can a course of development be defined with milestones and levels of expertise?
5. An evolutionary history and evolutionary plausibility-Can evolutionary antecedents be located?
6. Support from experimental psychological tasks-Does investigative evidence support the claim that particular abilities are manifested?
7. Support from psychometric findings-Can intelligence tests be developed to assess each intelligence?
8. Susceptibility to encoding in a symbol system-Can the intelligence be converted to a cultural symbol system? Examples of symbol systems include language, mathematics, and music.

Gardner's theory of Multiple Intelligences is based on two basic beliefs. First, all humans possess the capacity to all of the intelligences and second, that just as each person has unique physical and personality attributes we also have different patterns of intelligence (Merriam, Caffarella, & Baumgartner, 2007). From the beliefs and criteria

Gardner defines eight intelligences. Gardner's Multiple Intelligences are summarized in Table 4 (Tanner & Allen, 2004).

Table 4. Gardner's Theory of Multiple Intelligences

The Eight Intelligences	
Intelligence	***Is characterized by facility with…***
Linguistic-verbal	Words, language, reading, and writing
Logical-mathematical	Mathematics, calculations, and quantification
Visual-spatial	Three dimensions, imagery, and graphic information
Bodily-kinesthetic	Manipulation of objects, physical interaction with materials
Musical-rhythmic	Rhythm, pitch, melody, and tone
Interpersonal	Understanding of others, ability to work effectively in groups
Intrapersonal	Metacognitive ability to understand oneself, self-awareness
Naturalistic	Observation of patterns, identification, and classification

Yet another method, which is used in the current study, is the Felder-Silverman Dimensions of Learning Styles. Felder-Silverman Learning Style Model (FSLSM) is specifically built for college classroom use (Tanner & Allen, 2004). The Index of Learning Styles Survey (ILS) consists of 44 items, the answers to which are used to present a graphic depiction of the respondents learning style (Appendix A) (Tanner & Allen, 2004). The ILS Survey also provides a textual description of each learning style and provides insight to students on how they can tailor new material to his or her specific learning style (Tanner & Allen, 2004). The analysis is based on four modes related to the delivery and perception of material:

1. Type of information the student receives (sensory or intuitive).
2. The modality in which the student receives it (visual or verbal).
3. The process by which the student receives it (actively or reflectively)
4. The order in which the student receives the information (sequentially or globally).

The graphic depiction shows a continuum between the two extremes (sensory and intuitive, visual and verbal, active and reflective, sequential and global), highlighting the reality that students will often possess aspects of the two (Tanner & Allen, 2004).

Figure 1. Index of Learning Styles Graphic Output

```
ACT                             X                                    REF
     11   9    7    5    3      1    1    3    5    7    9    11
                               <--  -->

SEN        X                                                         INT
     11   9    7    5    3      1    1    3    5    7    9    11
                               <--  -->

VIS                             X                                    VRB
     11   9    7    5    3      1    1    3    5    7    9    11
                               <--  -->

SEQ             X                                                    GLO
     11   9    7    5    3      1    1    3    5    7    9    11
                               <--  -->
```

Students can also show a strong preference toward one of the extremes. A score of 1-3 represents a well-balanced preference between the two dimensions. A score of 5-7 represents a moderate preference for one dimension of the scale; learning will occur more easily in teaching environment which favors that dimension. A score of 9-11 represents a very strong preference for one dimension of the scale, learning will be difficult in an environment which does not support that preference.

The FSLSM is based on the ideas that students are constantly barraged with information, but only a portion of this information can be admitted to his or her working memory. Once information is presented, a selection process based on a student's preferences then comes into play. The FSLSM divides this initial selection process into sensory and intuitive learners. A sensory learner favors information that comes through their senses; listening, observation, and tactile experiences (Felder R. M., 1993). These students are often considered practical and tend to prefer material that they perceive as having an application in the "real world." They like facts and observations and do not mind detailed or repetitive work (Felder R. M., 1993). Sensors can easily memorize facts and prefer laboratory courses with hands on experience. Intuitive learners, on the other hand, have imaginative personalities that prefer abstract concepts and theories (Felder R. M., 1993). These individuals like variety and complexity and will tire of repetitive work (Felder R. M., 1993). Intuitive learners often perform better in physics and chemistry lecture courses than sensory learners (Felder R. M., 1993).

The preference of modality, visual or verbal, also plays a role in how new material is learned by a student. A visual learner prefers images such as diagrams, graphs, and schematics, while a verbal learner prefers written and spoken words (Felder R. M., 1993). A lecture course that does not contain demonstrations or experiments is often challenging for visual learners. Lecture courses are predominately purely auditory or a visual representation of auditory information. Thus verbal learners will outperform visual students in courses that are formatted primarily with lectures (Felder R. M., 1993).

The next domain included in the FSLSM defines the process by which information is received and processed. The extremes of the continuum are defined as active learners versus reflective learners. Felder defines active learners as individuals who work well in groups and tend to learn while doing something active, such as group discussion and problem solving (Felder R. M., 1993). Reflective learners have a tendency to work alone or in pairs; these individuals often feel the necessity to think through material alone before verbalizing his or her knowledge (Felder R. M., 1993). Although most higher education courses are typically taught in a lecture format, this modality does not appeal to either group of students (Felder R. M., 1993). Lecture courses are considered passive learning and instructor-centered (Felder R. M., 1993).

The final FSLSM learning style attribute accounts for the method in which students best attain an understanding of new material (Felder R. M., 1993). Sequential learners learn in a linear progression with connected incremental information (Felder R. M., 1993). These individuals have the capability of solving problems without necessarily grasping the big picture (Felder R. M., 1993). Global learners cannot master the steps of problem solving until they have a grasp of the total picture (Felder R. M., 1993). Global learners make intuitive leaps and often will be unable to explain how they came up with the solution (Felder R. M., 1993).

Learning Styles and Student Success

Improving student performance is becoming more and more challenging for instructors. It is intuitive to think that teaching in a method that a student learns best

would enhance student performance. Some research proposes that knowledge of a learning style can be beneficial to both the student and instructor (Romanell et al., 2009). For example, such knowledge allows the instructor to incorporate teaching components tailored to each learning style. Conversely, a student may use the knowledge of his or her own learning style to enhance and expand his or her academic capabilities by converting information to one of his or her own learning preferences (Romanell et al., 2009). The research studying the association between learning style and student performance show the controversy that exists. Studies range from weak positive correlations to no significant correlation.

Investigators at the University of Florida used the VARK method to compare learning style preferences and gender, status, and course performance for an exercise physiology course (Dobson, 2010). Fifty undergraduate and fourteen graduate students were asked to complete a survey that assessed perceived learning style and actual learning style. The first section of the survey asked the students to select his or her perceived VARK learning style based on short descriptions of each style. The second portion included 16 questions the investigators used to assess the actual VARK learning style. Seventy percent of the sample was assessed as being multimodal with two or more learning styles. Fifty-nine percent of the assessed dominant learning styles matched the perceived student learning styles. Twenty-two percent of the multimodal students chose one of his or her learning styles but not the assessed dominant style. Nineteen percent of the students perceived learning style did not match his or her assessed learning style. Statistical analysis showed no significant difference between

learning style and class status or sex and learning style, X^2 =1.55, P=0.67 and X^2 =7.18, P=0.06, respectively (Dobson, 2010). A significant association was observed between perceived learning style and course performance (F= 4.13, P=0.01) but not between assessed learning style and course performance (Dobson, 2010). In fact, Bonferroni post hoc testing showed that students with perceived kinesthetic learning style had significantly lower scores than the three other learning styles. The mean scores for perceived visual learners were 86.63±8.68, aural learners were 88.31±4.35, reading and writing learners were 86.62±5.42, and kinesthetic learners were 78.96±8.61 (Dobson, 2010).

In another study completed by Horton et al (2011), the association between student learning and academic performance were found to be weakly correlated. The investigators set out to study two hypotheses; academic performance is related to lecture attendance and a student's learning style influences lecture attendance and consequently affects academic performance. One hundred and twenty students enrolled in a physiology course self-reported on lecture attendance and the use of posted lecture recordings. Over the course of the semester, 21 lectures were scheduled and overall attendance was 73±2% (Horton et al., 2011). Academic performance was assessed by final exam scores, laboratory practicals, and final course scores. Final exam scores correlated weakly with lecture attendance, $r(119)=0.21$, $P<0.002$. Laboratory practical scores correlated positively with lecture attendance, $r(119)=0.29$, $P<0.002$. Final scores were also positively correlated with lecture attendance $r(119)=0.31$, $P<0.001$. To address the second hypothesis, data from 83 students VARK

surveys were analyzed. The students assess his or her own learning styles based on 4 statements for each of the VARK modalities and also completed the VARK questionnaire. The students significantly over predicted his or her V and R styles ($P<0.001$ and $P<0.015$) and under predicted his or her A and K styles ($P<0.001$ and $P<0.015$) (Horton et al., 2011). There were no significant differences between VARK modalities and lecture attendance. There were also no correlations between visual, aural, and kinesthetic learning styles and any of the academic performance scores. However, the reading and writing learning style was weakly correlated with the final exam scores $r(82)=0.22$, $P<0.03$. The investigators concluded that although some statistical significance existed between lecture attendance and academic performance, the correlations were consistently weak (Horton et al., 2011).

To determine if learning styles contributed to student success, a study was completed on two sections of an undergraduate management course (Neuhauser, 2002). One section was a traditional face-to-face course and the second was an online format. The sample of 62 students were taught the 15 week course by the same instructor and presented the same instructional materials. The students completed a learning style survey similar to VARK called the Learning Modality Preference Inventory. The instrument measures the preference for visual, auditory, or kinesthetic modality. Of the online students who achieved a grade of “A” or “A-,“ 40% were assessed as visual or as one learning preference of the student if they were multimodal and 66% were assessed as kinesthetic or as one preference if multimodal (Neuhauser, 2002). The face-to-face students were assessed at 43% as visual and 43% as kinesthetic learners.

Statistical analysis showed that there was no significant relationship between learning style and course performance for either section. The investigator concluded that a specific learning style preference is not a good predicator of student success in an online or face-to-face course (Neuhauser, 2002).

Investigators at the University of Illinois at Champaign-Urbana also examined learning style preferences and course performance in two learning environments (Aragon, Johnson, & Shaik, 2002). The sample population consisted of 36 students enrolled in a graduate human resource instructional design course. Both sections contained 19 students and were taught by the same instructor covering the same instructional topics. Statistical analysis showed that the online students had a higher preference for abstract conceptualization and reflective learning than his or her face-to-face counterparts $F(1,35)=4.46$, $p<0.05$ and $F(1,35)=4.77$, $p<0.05$, respectively (Aragon et al., 2002). On the other hand, the face-to-face students were found to prefer active experimentation or learning by doing as compared to the online students $F(1,35)=6.48$, $p<0.05$. Although there were significant differences in learning style, there were no significant differences in course performance. Again the investigators concluded that learning style preferences have no effect on course performance if a course is well developed, regardless of the platform (Aragon et al., 2002).

Chapter Two

METHODS

Research Design

The study was completed on two Medical Microbiology laboratory sections at the University of Wisconsin-Milwaukee (UWM) during the Spring 2011 semester. The Medical Microbiology lab is a required course for Biomedical Sciences, Cytotechnology, Medical Laboratory Sciences, and the Public Health Microbiology Baccalaureate of Science degree programs, housed within the Biomedical Sciences program. Each laboratory section is a 16 week course which consists of 2 laboratory sessions each week, for a total of 30 sessions per section. Each week all students were required to complete a 22-29 question online quiz before the start of the laboratory. The first laboratory session of each week began with a 10 to 15 minute lecture describing the organisms and microbiology methods pertaining to that week. A four to five question review quiz utilizing an audience response system followed several of the lectures. During the second laboratory session, the students recorded observations for each organism studied. The course schedule was as follows:

Week 1-Laboratory Safety

Week 2-*Staphylococcus* spp.

Week 3-*Streptococcus* spp.

Week 4-Gram positive bacilli

Week 5-*Neisseria* spp.

Week 6-*Haemophilus* spp.

Week 7-Enterobacteriaceae

Week 8-Enterobacteriaceae

Week 9-No class

Week 10-Lab Practical Exam 1

Week 11-Non-fermentative Gram negative bacilli

Week 12-*Vibrio, Campylobacter, Aeromonas,* and *Plesiomonas* spp.

Week 13-*Bordetella bronchiseptica* and *Pasteurella multocida*

Week 14-Anaerobic Bacteria

Week 15-Antimicrobial Susceptibility Testing

Week 16-Lab Practical Exam 2

The study was conducted using the same two defined groups throughout the course of the semester. The two groups were convenience samples, meaning that the laboratory section, chosen by the student, dictated which group he or she was a part of. One section was designated as the control group and the other as the experimental group. The control group was taught in the traditional manner that has been taught for the previous 3 years. In addition to the traditional course materials, the experimental

group was required to spend ten minutes each week on web-based educational aids; specifically StudyMate learning modules and one PowerPoint review file consisting of images.

Participants Exclusion/Inclusion Criteria

Inclusion criteria for the study samples included documentation of ten minutes spent on StudyMate for no less than twelve weeks during the semester, met the prerequisites for the Medical Microbiology lab, consent for UWM transcripts, and were enrolled as undergraduate students. The prerequisites for Medical Microbiology laboratory included courses in general chemistry, organic chemistry, general microbiology, and Medical Microbiology lecture. Exclusion criteria included graduate student standing, documentation for 2 weeks of less than ten minutes of StudyMate participation, failure to meet prerequisites for Medical Microbiology Laboratory, and declined consent for UWM transcript access.

The study samples consisted of students enrolled in two sections of Medical Microbiology Laboratory at the University of Wisconsin-Milwaukee. Twenty-four students enrolled in the experimental group section. The number of students included in the experimental groups was 16 (n=16). Four students chose not to participate in the StudyMate lessons and were automatically placed in the control group. Two students were excluded from the study on the basis of having more than two weeks of unregistered StudyMate times. One graduate student was excluded from the experimental groups as well as one student who did not meet the course prerequisites.

Eighteen students were enrolled in the control group laboratory section. Two students chose not to disclose transcript information and were excluded from the study. One graduate student was excluded from the control group and data analysis. With the additional four students from the first laboratory section the total number of students included in the control group was 19 (n=19).

Table 5. Study Participant Demographics

	Control Group	Experimental Group
Number of participants (n)	19	16
Median age	25.6	27.3
Number of Females	12	12
Number of Males	7	4

The study adhered to procedures for the protection of human subjects and was conducted with permission of the University of Wisconsin-Milwaukee Institutional Review Board, IRB # 11.160. Personal identification was removed from all data to maintain anonymity and confidentiality throughout the study.

Instruments

The primary resource for the experimental group was an internet-based program called StudyMate, which is available in conjunction with the Desire2Learn (D2L) course management website utilized by UWM. StudyMate is a useful tool for courses with large amounts of facts and materials that require memorization (StudyMate Author Workshop, 2010). The program has ten types of games and activities that vary based on what types of material are imported. There are three forms of information that can be imported into the program: text, audio files, and graphic images (StudyMate Author

Workshop, 2010). The instructor determined the type and form of information imported into StudyMate. The student then chose the activity format he/she wished to utilize each week. The items are randomized each time a student starts a new learning game (StudyMate Author Workshop, 2010). The D2L website monitored the amount of time a student spent on each module but not the type of activity chosen (StudyMate Author Workshop, 2010). Approximately 150 items were designed for the students to access throughout the semester. Appendix C depicts screen shot examples of the StudyMate activities available to students. Modules were available for each laboratory topic one week before the laboratory and were available throughout the semester. In addition, a PowerPoint presentation was created to simulate a laboratory practical examination. The PowerPoint consisted of twenty-five slides corresponding to the twenty-five organisms and biochemical reactions discussed in class up to that point in the course.

Data were obtained from University of Wisconsin-Milwaukee transcripts, two engagement surveys (Appendix B), and Index of Learning Styles survey (ILS survey, Appendix A). The engagement surveys were identical in format. The initial survey was administered to both the control and experimental group during the first laboratory session. The final engagement survey was administered to both groups during the last laboratory session. The survey was developed through the aid of a statistician and was not examined for validity but rather used to indicate change from beginning engagement to final engagement. The survey consisted of two components. The first component used a Likert scale to assess three constructs: cooperation with peers, active

learning, and faculty-student interaction. The second component contained open ended questions concerning previous education and how the students spent his or her time.

The Index of Learning Style (ILS) survey was developed by Dr. Richard Felder and Dr. Linda K. Silverman from North Carolina State University for use by college instructors and students in engineering and the sciences. Students in both the control and experimental group completed the survey during the first laboratory session. The learning styles for each student were determined using the website version of ILS Questionnaire (Solomon & Felder) http://www.engr.ncsu.edu/learningstyles/ilsweb.html. Several validation studies have been performed on the ILS survey by outside (see Graf, Viola, & Leo, 2007, Litzinger, Ha, Wise, & Felder, 2007, and Felder & Spurlin, 2005).

Data analysis

All data were entered into Microsoft Excel 2010 and then imported into R version 2.10.1 for data analyses. R is a free statistical analysis environment designed for data manipulation, calculation, and graphical displays. Graphs, charts and tables were created using Microsoft Excel 2010 and Microsoft Word 2010. Significance was set at $p<0.05$.

Data were analyzed as follows:

Independent sample t-tests were performed on normally distributed data to determine if a significant difference existed between the two groups for the following variables:

- Microbiology Lecture final grade
- Microbiology Laboratory final grade
- Midterm Laboratory Practical grade
- Final Laboratory Practical grade
- Science grade point average (G.P.A.)
- Overall G.P.A.
- Engagement Survey Parameters
    - Initial Cooperation with peers
    - Initial Active Learning
    - Final Cooperation with peers
    - Final Active Learning
    - Final Faculty Student Interaction
    - Semesters Completed
    - Initial and Final Cooperation with peers
    - Initial and Final Active Learning

Mann-Whitney tests were performed on data not normally distributed to determine if a significant difference existed between the two groups for the following variables:

- Engagement Survey Parameters
    - Initial Faculty Student Interaction

  - Part-time enrollment
  - Hours per week spent preparing for class
  - Hours per week spent working on campus
  - Hours per week spent working off campus
  - Hours per week spent commuting
  - Hours per week spent relaxing
  - Hours per week spent caring for a dependent
  - Hours per week spent on extracurricular activities
  - Initial and Final Faculty Student Interaction

Correlation studies were performed to determine the relationship for the following variable sets:

- Microbiology Laboratory course grade and overall grade point average (G.P.A.)
- Microbiology Laboratory course grade and Science G.P.A.
- Microbiology Lecture course grade and Overall G.P.A.
- Microbiology Lecture course grade and Science G.P.A.
- Microbiology Lecture course grade and Active/Reflective Learning
- Microbiology Laboratory course grade and Active/Reflective Learning

Chapter Three

RESULTS AND ANALYSIS

The emphases on a quality education and the retention of students in the university setting have become major topics of discussion among academic experts. Institutions of higher learning are constantly challenged to improve student performance and retention. These issues are complicated by the increase in nontraditional students, creating a diverse classroom with respect to age and life experiences. A variety of approaches have been evaluated to improve student performance and retention. Student engagement has been correlated with student retention and improved student performance (Svanum & Bigatti, 2009) (Wolf-Wendel, Ward, & Kinzie, 2009). This study specifically addressed the approach of student engagement through the use of online educational aids. Additional education aids will provide another avenue for student engagement. Performing statistical analysis on the course grades for the control and experimental group will provide mathematical evidence of the effects of additional learning aids.

Rationale and Purpose

The study described here investigated the relationship between providing additional educational aids on academic performance and student engagement in a junior level Medical Microbiology course at the University of Wisconsin-Milwaukee. Student engagement has been correlated with student retention and student performance. Providing additional online learning aids falls within the 4th benchmark of

"effective educational practices," measured by the NSSE survey: enriching educational experiences. Analysis of student learning styles on the basis of the Index of Learning Styles survey addresses the effectiveness of the educational aids. Statistical analysis of overall grade point average (GPA), science GPA, Medical Microbiology lecture grades, Medical Microbiology laboratory grades, and student learning styles, along with an engagement survey, provide insight to the level of student engagement for those students enrolled in Medical Microbiology. This evidence can then be used to make improvements in future course work.

Pre-implementation

To assure that the experimental and control groups were academically similar, transcripts were obtained and the overall GPA and the Science GPA were compared. In addition, all students took the Index of Learning Styles survey to ascertain the learning styles of participants in each group. Analysis of the control and StudyMate experimental group before the implementation of the StudyMate Lessons demonstrated that no significant difference existed on the basis of Science Grade Point Average (GPA), overall GPA, or learning style (Figure 2, 3, and Table 6).

Figure 2. Pre-implementation Science GPA

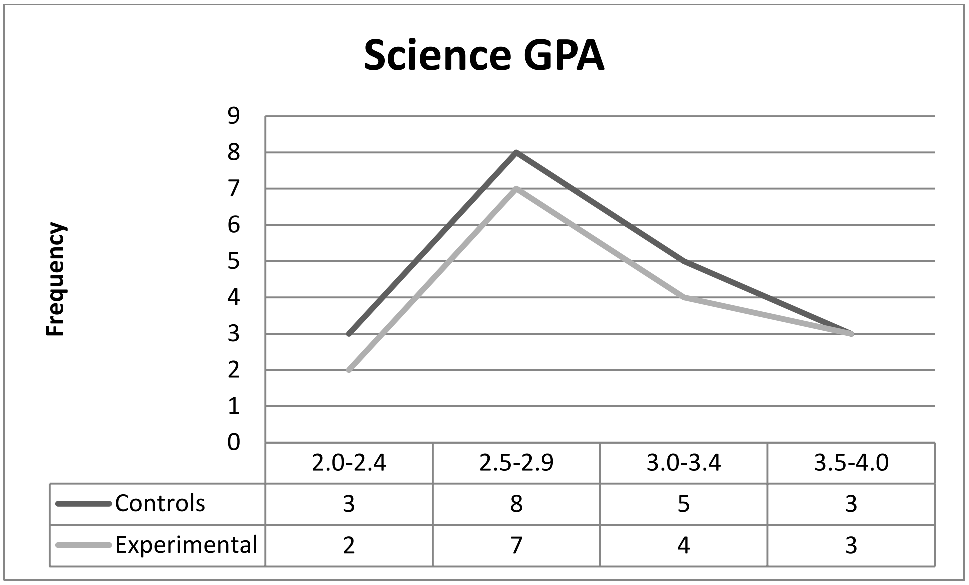


Figure 2. Comparison between the Control and StudyMate experimental group Science GPA before implementation of StudyMate activities. There was not a significant difference in Science GPA for the Control (*M*=3.02, *SD*=0.43) and the Experimental (*M*=3.02, *SD*=0.52) groups: *t*(34)=0.0019, *p*=0.99.

Figure 3. Pre-implementation Overall GPA

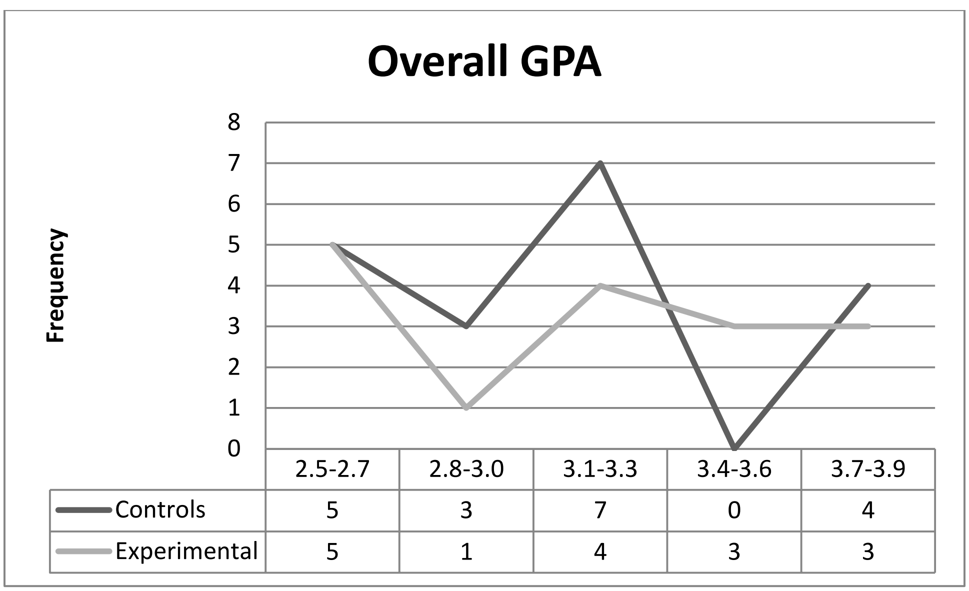


Figure 3. Comparison between the Control and StudyMate Experimental group Overall GPA before implementation of StudyMate activities. There was not a significant difference in Overall GPA for the Control (*M*=3.17, *SD*=0.44) and the Experimental (*M*=3.25, *SD*=0.48) groups: *t*(34)=0.51, *p*=0.99.

Table 6. Student Learning Styles

	Control Group		Experimental Group	
Learning Style	Frequency	% of group	Frequency	% of group
Active	6	33	3	20
Reflective	12	67	12	80
Sensing	13	72	13	87
Intuitive	5	28	2	13
Visual	15	83	14	93
Verbal	3	17	1	6
Sequential	15	83	10	67
Global	3	17	5	33

Table 6. Index of Learning Style experimental and control group frequencies. There was no significant difference based on a p-value of $p<0.05$ between experimental and control group learning styles.

Post-Implementation

To determine if online study aids had an effect on learning, midterm and final laboratory practical grades and final grades in the Microbiology course were compared between the experimental and control group. Analysis of midterm laboratory practical grades and final laboratory practical grades after the implementation of the StudyMate Lessons also showed no significant difference between the control and experimental groups (Figure 4 and 5). Analysis of Medical Microbiology percentage grades post-implementation also demonstrated no significant differences between the control and experimental groups (Figure 6 and 7).

Figure 4. Midterm Laboratory Practical Grade

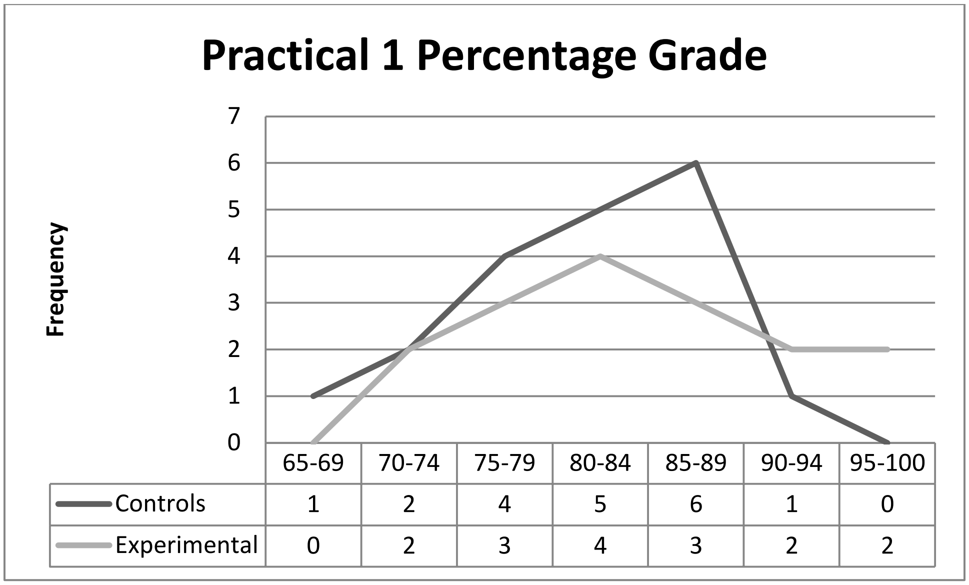


Figure 4. Comparison between the Control and StudyMate experimental group Midterm Laboratory Practical percentage grade. There was not a significant difference in Midterm Laboratory Practical percentage grade for the Control (*M*=81.74, *SD*=6) and the Experimental (*M*=84.31, *SD*=7.56) groups: *t*(34)=1.10 *p*=0.28.

Figure 5. Final Laboratory Practical Grade

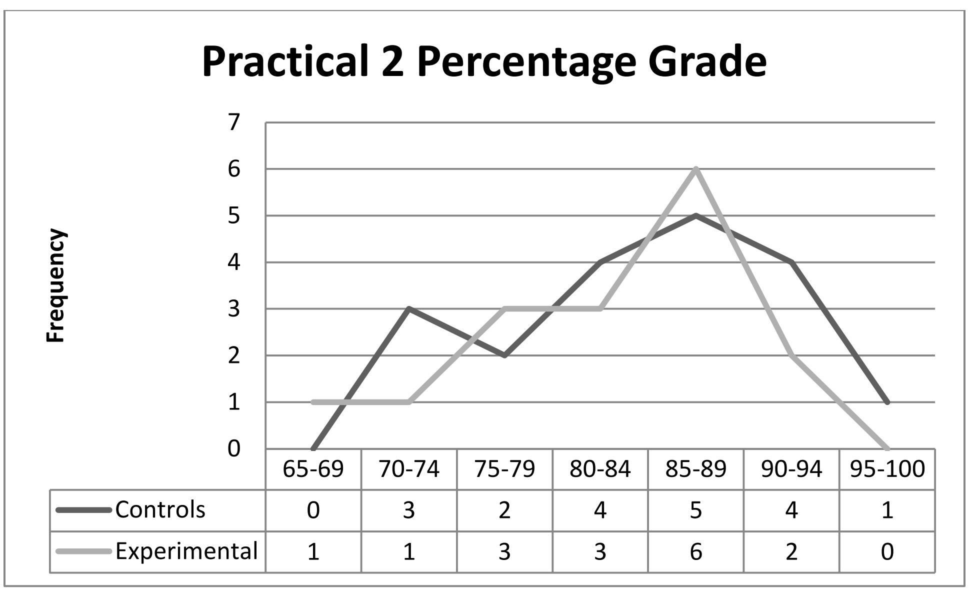


Figure 5. Comparison between the Control and StudyMate experimental group Final Laboratory Practical percentage grade. There was not a significant difference in Final Laboratory Practical percentage grade for the Control (*M*=84.68, *SD*=7.58) and the Experimental (*M*=83.36, *SD*=6.59) groups: *t*(34)=-0.55, *p*=0.58.

Figure 6. Post-implementation Lecture Grade

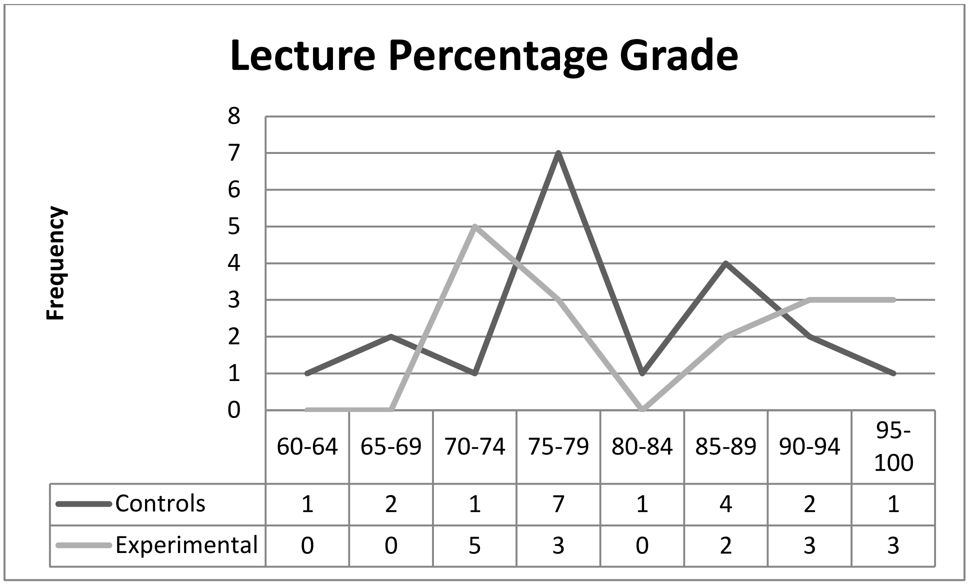


Figure 6. Comparison between the Control and StudyMate Case group Medical Microbiology Lecture percentage grade. There was not a significant difference in Medical Microbiology Lecture percentage grade for the Control (*M*=79.98, *SD*=9.16) and the Experimental (*M*=84.01, *SD*=10.47) groups: *t*(34)=1.19, *p*=0.24.

Figure 7. Post-implementation Lab Grade

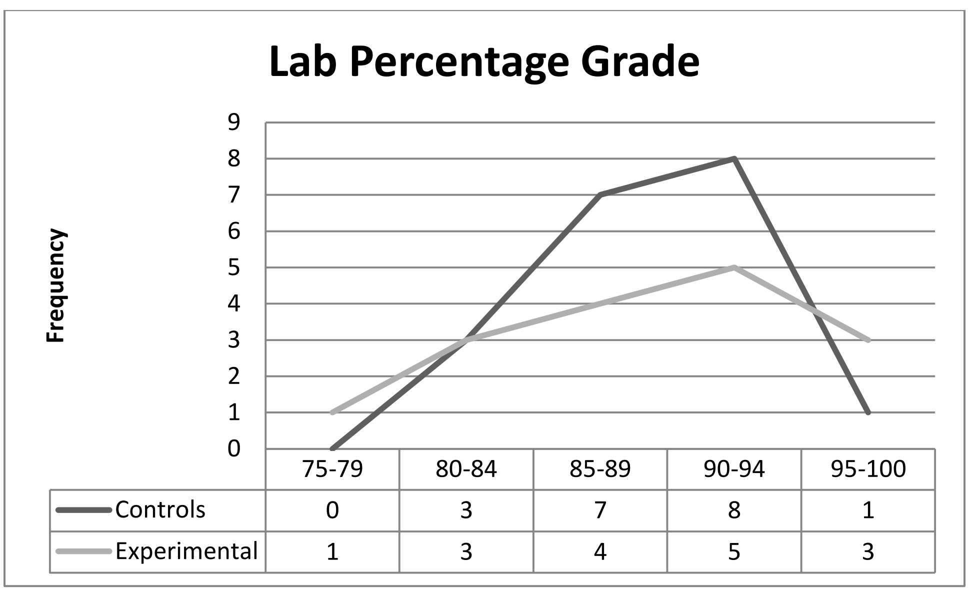


Figure 7. Comparison between the Control and StudyMate experimental group Medical Microbiology Laboratory percentage grade. There was not a significant difference in Medical Microbiology Laboratory percentage grade for the Control (*M*=89.69, *SD*=4.07) and the Experimental (*M*=89.38, *SD*=1.32) groups: *t*(34)=-.19, *p*=0.85.

Engagement Survey

In order to assure the two groups were similar in respect to engagement, a survey was administered during the first laboratory session and on the last day of laboratory. This engagement survey consisted of two components. The first component used a Likert scale to assess three constructs; cooperation with peers, active learning, and faculty-student interaction. The second components contained open-ended questions concerning previous education and how the students spend his or her time. The engagement survey analysis affirmed that the level of engagement for the control and experimental group did not differ before or after the implementation of the StudyMate lessons (Table 7 and 8).

Table 7. Initial Engagement Survey Results for Open Ended Questions.

	Control			Experimental		
	Mean	SD	SE	Mean	SD	SE
Total Semesters	7.88	2.23	0.51	10	2.9	0.72
Preparing for class	24.29	18.57	4.26	13.93	7.88	1.97
Commuting	5.26	5.61	1.29	4.97	3.09	0.77
Relaxing/Socializing	14	22.65	5.20	10.33	6.56	1.64
Working on campus	3.33	8.4	1.93	2.5	6.52	1.63
Working off campus	13.11	11.85	2.72	20.12	16.69	4.17
Caring for a dependent	5	12.44	2.85	7.18	8.99	2.25
Extra-curricular activities	3.33	4.97	1.14	2.5	5.14	1.28

Table 7. Student responses on the Initial Engagement Survey show no significant difference between groups with a $p<0.05$. Data not shown Final Open Ended questions for Final Engagement Survey also show no significant difference between the groups. With the exception of Total Semesters, all data are expressed as hours per week.

Three engagement constructs were analyzed in the initial and final engagement surveys. Cooperative learning as defined by the National Survey of Student Engagement is the act of solving problems and mastering difficult material within a group of students. Active learning requires students to actively participate in his or her education through activities such as discussions and in-class debates. The final engagement construct analyzed was the faculty-student interaction; the relationship between faculty members and students both inside and outside the class room (National Survey of Student Engagement, 2011).

Table 8. Engagement Survey Results for Engagement Constructs.

		Initial Engagement Survey			Final Engagement Survey		
		Mean	SD	SE	Mean	SD	SE
All	Cooperation	8.14	2.25	0.38	8.31	2.38	0.4
	Active Learning	9.66	1.76	0.3	10.11	1.73	0.29
	FS Interaction	6.71	2.62	0.44	7.34	1.93	0.33
Control	Cooperation	8.47	2.41	0.55	8.95	2.76	0.63
	Active Learning	9.89	1.91	0.44	10.26	1.94	0.45
	FS Interaction	7.16	2.65	0.61	7.63	2.36	0.54
Exp.	Cooperation	7.75	1.82	0.46	7.56	1.84	0.46
	Active Learning	9.38	1.61	0.4	9.94	1.45	0.36
	FS Interaction	6.19	2.63	0.66	7	1.11	0.28

Table 8. Student responses in the Engagement Constructs section did not differ for the group as a whole or within each group on the Final or Initial Engagement Survey with a $p<0.05$.
FS=Faculty Student Interaction Exp=Experimental

Correlation Studies

Correlation studies were performed to determine predictors for Medical Microbiology grades. Guidelines from *Applied Statistics: From Bivariate through Multivariate Techniques* by Rebecca M. Warner were used to determine correlation coefficient strengths (Warner, 2008). As defined by this source, an *r* value of less than

0.30 represents a weak linear relationship, $0.3<r<0.7$ represents a moderate linear relationship, and $0.7<r<1.0$ indicates a strong linear relationship. A Pearson product-moment correlation coefficient was computed to assess the relationship between Medical Microbiology Laboratory grades and overall GPA as well as Science GPA (Table 9). There was a moderate positive correlation for the entire group of students between Medical Microbiology laboratory grades and overall GPA, Pearson's $r(33) = 0.47$, $p = 0.004$. A moderate positive correlation also existed for the experimental group laboratory grades and science GPA, Pearson's $r(33) = 0.59$, $p = 0.01$. However, a significant correlation was not seen for the control group and science GPA, Pearson's $r(33) = 0.16$, $p = 0.52$. There was a strong positive correlation for the entire group of students between Medical Microbiology lecture grades and overall GPA, Pearson's $r(33) = 0.7$, $p < 0.001$, as well as for lecture grade and science GPA, Pearson's $r(33) = 0.72$, $p < 0.001$.

Table 9. Correlations between Medical Microbiology Grades and GPA

		Controls		Experimental		All	
%Grade		r	r2	r	r2	R	r2
Laboratory	Overall GPA	0.45	0.2025	0.5	0.25	0.47	0.2209
	Science GPA	0.16	0.0256	0.59	0.3481	0.41	0.1681
Lecture	Overall GPA	0.6	0.36	0.79	0.6241	0.7	0.49
	Science GPA	0.63	0.3969	0.82	0.6724	0.72	0.5184

Table 9. With the exception of Control group Laboratory grades and Science GPA; all Pearson's r values were significant at the 0.05 level (2-tailed).

Analysis of student learning styles and Medical Microbiology grades also show several positive correlations (Table 10). The entire group as a whole demonstrated a

moderate positive correlation between laboratory grades and active-reflective learning style preference, as well as lecture grades and active-reflective learning style preference, Pearson's *r*(33) = 0.43, *p* =0.01 and Pearson's *r*(33) = 0.39, *p* = 0.02, respectively. A moderate positive correlation also existed for the control group between laboratory grades and active-reflective learning preference, Pearson's *r*(33) = 0.5, *p*=0.03. Scatterplots depicted in Figure 8 and Figure 9 summarizes these significant results.

Table 10. Correlations between Medical Microbiology Grades and Learning Styles

% Grade		Controls		Experimental		All	
		r	r2	r	r2	R	r2
Laboratory	ACT.REF	0.5*	0.25*	0.39	0.1521	0.43*	0.1849*
	SEN.INT	-0.36	0.1296	-0.07	0.0049	-0.16	0.0256
	VIS.VRB	0.16	0.0256	-0.04	0.0016	0.07	0.0049
	SEQ.GLO	0.02	0.0004	0.03	0.0009	0.02	0.0004
Lecture	ACT.REF	0.39	0.1521	0.42	0.1764	0.39*	0.1521*
	SEN.INT	-0.19	0.0361	-0.16	0.0256	-0.24	0.0576
	VIS.VRB	0.12	0.0144	-0.14	0.0196	-0.07	0.0049
	SEQ.GLO	-0.11	0.0121	0.01	0.0001	-0.01	0.0001

Table 10. * Pearson's r values were significant at the 0.05 level (2-tailed). SEN.INT=Sensing-Intuitive learners, ACT.REF=Active-Reflective learners, VIS.VRB=Visual-Verbal learners, SEQ.GLO=Sequential-Global learners.

Figure 8. Learning Style Preference and Medical Microbiology Laboratory Grade Correlation

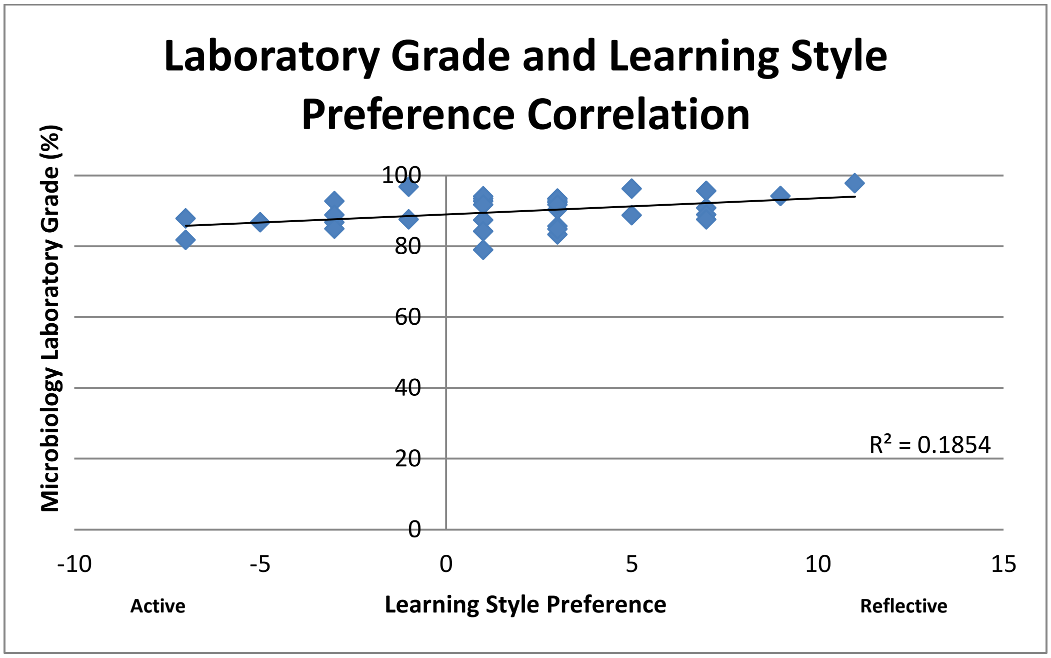
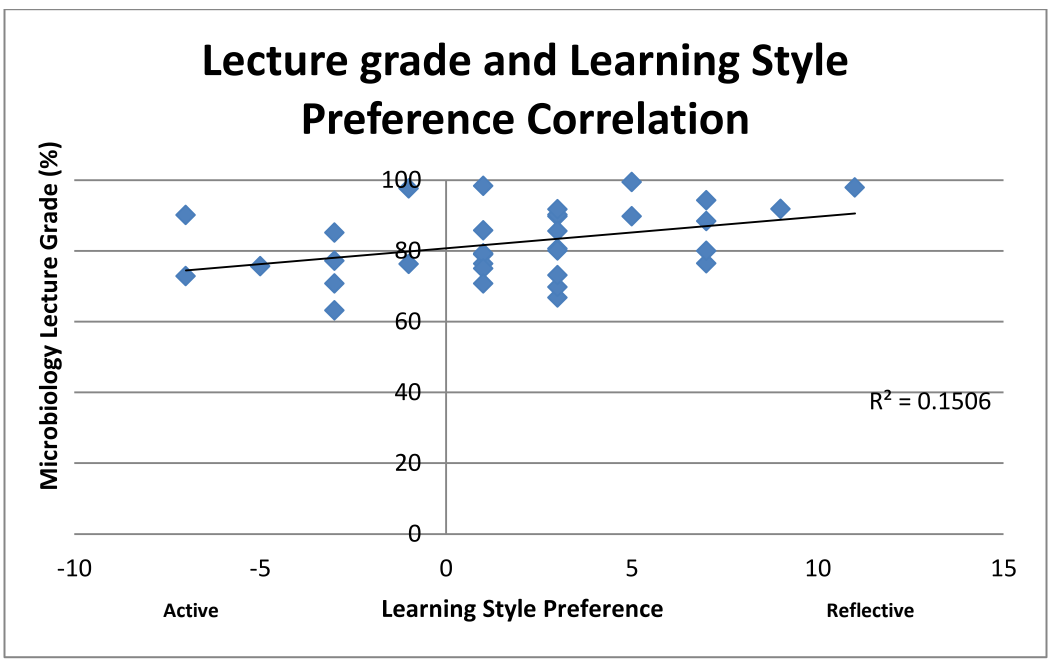


Figure 9. Learning Style Preference and Medical Microbiology Lecture Grade Correlation



Chapter Four

DISCUSSION AND CONCLUSIONS

Study Design Summary

This study investigated the potential of improved student engagement through the use of computer-assisted instruction, specifically the use of the program StudyMate^{TM} (Respondus© Inc, Redmond, WA). The study was completed on two Medical Microbiology laboratory sections at the University of Wisconsin-Milwaukee (UWM) during the Spring 2011 semester. The study was conducted using the same two defined groups throughout the course of the semester. The two groups were convenience samples, meaning that the laboratory section, chosen by the student, dictated which group he or she was a part of. One section was designated as the control group and the other as the experimental group. The control group was taught in the traditional manner that had been taught for the previous 3 years. In addition to the traditional course materials, the experimental group was required to spend ten minutes each week on web-based educational aids; specifically StudyMate learning modules and one PowerPoint review file consisting of images.

Statistical Analysis Summary

To ascertain that no significant differences in key indicators of student engagement or success prior to intervention, the following variables were characterized in the experimental and control groups: Pre-implementation overall GPA and science GPA, Initial Engagement Survey, and Learning Style Preferences. Of importance to the analysis and interpretation of the current results, no significant differences between the two groups were found in these key variables. Thus, it was not necessary to correct for any pre-existing conditions.

The post-implementation statistical analysis found no significant difference between the groups for the following factors: Midterm Laboratory Practical Grade, Final Laboratory Practical Grade, Lecture Grade, Laboratory Grade, and Final Engagement Survey. These results differ from the established literature. For example, the Gopal et al. (2010) study demonstratesthat those students in an anatomy and physiology course who utilized an interactive web site performed better than students who had not. A larger study published by Allen, Walls, and Reilly (2008) also produced similar results. Students using online tutorials out preformed his or her classmates on exam questions relating to the material covered in the online tutorials (Allen, Walls, & Reilly, 2008).

An aspect of the current study that did provide statistical significance was the correlation between learning styles and Medical Microbiology grades. The analysis shows that a student with a reflective learning style can be used to predict higher performance in Medical Microbiology than a student with an active learning style. This seems contradictory in the description of a reflective and active learner. A reflective learner tends to think before acting, while an active learner is described as being an experimentalist (Felder, 1993). However, the microbiology lab design is structured in such a manner that it is conducive to reflective learners. The course met twice a week for two hours each session, with a number of tasks that had to be completed during each lab. The most successful students were those who came to lab prepared and with a plan. Reflective learners would be more adept to review lab procedures before coming to class. Active learners have an attitude of “let’s try it and see what happens” (Felder, 1993).   However, the reflective learners “let’s think it through first” attitude is more beneficial for time management during lab; if mistakes were made labs could not be repeated.   The ability to determine and analyze microbiology laboratory tests require foresight and not a “let’s try it and see what happens” type of attitude (Felder, 1993).

Comparing the Medical Microbiology students to UWM seniors, several disparities become apparent. For example, Table 11 shows that Medical Microbiology students worked less with other students outside of class, participated less in class discussion, and had less faculty-student interaction than UWM seniors. UWM seniors showed significant negative differences in these areas as well when compared to the Urban University and Carnegie University students, thus widening the gap between the students included in this study and the average engagement level among his or her peers. However, the Medical Microbiology students did show positive attributes in coming to class with assignments completed and revising a paper two or more times before completion as compared to UWM seniors. When comparing the time usage between the Medical Microbiology students and UWM seniors no significant differences were found (Table 12). The UWM seniors spent less time commuting and more time working on campus than Urban University seniors. Overall, the UWM students are statistically less engaged than his or her peers at comparable institutions.

Table 11. NSSE 2011 Academic and Intellectual Experiences Analysis including Medical Microbiology Students (MMS) and Senior Level University Student Responses

In your experience at your institution during the current school year, about how often have you done each of the following? 1=Never, 2=Sometimes, 3=Often, 4=Very often

Engagement Construct		MMS	UWM	Urban Universities	Carnegie Universities
Cooperation with Peers	Worked with other students on a project outside of class	2.14***	2.59	2.64	2.81***
Active Learning	Asked questions or contributed to class discussion	2.63***	2.97	3.08***	3.05**
	Come to class without completing assignments	1.29***	2.13	2.07*	2.11
	Revised a paper two or more times before handing the assignment in	3.09***	2.39	2.50***	2.45
Faculty-Student interaction	Worked with a faculty member on a research project	1.4	1.56	1.66***	1.80***
	Discussed grades or assignments with an instructor	1.97***	2.61	2.77***	2.80***
	Discussed career plans with a faculty member	1.83*	2.19	2.25*	2.36***

One, two, or three asterisks, referring to three significance levels (p<.05, p< .01, and p<.001) compared to UWM Seniors.

Table 12. NSSE 2011 Time Usage Analysis including Medical Microbiology Students (MMS) and Senior Level University Student Responses

About how many hours do you spend in a typical 7-day week doing each of the following? 1=0 hrs/wk, 2=1-5 hrs/wk, 3=6-10 hrs/wk, 4=11-15 hrs/wk, 5=16-20 hrs/wk, 6=21-25 hrs/wk, 7=26-30 hrs/wk, 8=More than 30 hrs/wk

	MMS	UWM	Urban Universities	Carnegie Universities
Preparing for class	4.72	4.31	4.22	4.37
Work on campus	2	1.96	1.64***	1.92
Work off campus	4	4.15	4.26	3.34***
Commuting	2.42	2.47	2.58***	2.43
Relaxing	3.17	3.54	3.37**	3.51
Caring for a dependent	2.14	2.35	2.96***	2.34
Extracurricular activities	1.75	1.62	1.71*	2.12***

One, two, or three asterisks, referring to three significance levels (p<.05, p< .01, and p<.001) compared to UWM Seniors.

Limitations

A number of factors in the current study could contribute to the lack of significant improvement in the experimental group compared to the control group. The sample sizes in the present study were small (Experimental group, n= 16; Control group, n=19). A larger sample size like that of the Allen, Walls and Reilly study (N=856 students) may reveal a statistical difference in student performance and student engagement between groups. Another unforeseen factor that may have affected the result was lack of instructor experience. During the semester in which the current study took place both the lecture and laboratory sections were taught by new instructors with little to no teaching experience. Developing a teaching style takes several attempts to master and discern techniques that effectively convey new material. New instructors may have reduced the possibility of positive outcomes.

Limitations of StudyMate, used to design study aids, could have also affected the results. The StudyMate lessons were primarily in the format of written words describing Medical Microbiology material. Ninety-three percent of the students in the experimental group were classified as visual learners. The written descriptions would not be the preferred modality for a majority of the students. However, the twenty-five organism PowerPoint presentation would be a perfect modality for the visual learners. The StudyMate program did not have the capacity for the large amounts of visual material that interpreting microbiology testing requires. The results could be adversely affected by the limited amount of time students were required to spend with the StudyMate materials. The required weekly time spent was 10 minutes; requiring a lengthier study time may then produce a statistical difference. Statistical analysis did not show a significant difference for time spent on StudyMate within the experimental group.

A major concern in the present study was the possibility of a student from the experimental group sharing the online learning aids with students in the control group. Although an instructor should be open to providing additional resources to all students, the ability to monitor the contribution of additional activities on student scores is the purpose of this study. There was evidence that students were sharing the StudyMate lessons and PowerPoint images. Printed copies of the lessons and PowerPoints were shared between the experimental and control groups. Another limitation was the ability to monitor the time spent on StudyMate. Some unforeseen problems arose when students used internet browsers other than internet explorer. During the course of the study the instructor posted the lessons approximately a week before each laboratory. Because the course met twice a week the instructor was able to post a list of students who had yet to complete the required ten minutes for the week. Through this practice it came to light that the time spent on StudyMate was not being monitored for those students who used Google Chrome as his or her internet browser. Several students preferred to use Google Chrome which seemed to be incompatible with the time monitoring program associated with Desire2Learn.

The diversity of the students taking the Medical Microbiology course may affect the comparison of the two groups. One consideration is the length of time since the student has taken a general microbiology course. It is reasonable to expect that those students who have taken general microbiology in the previous semester have an advantage over those with a longer duration between general microbiology and medical microbiology. The general microbiology course introduced the basic concepts and techniques of microbiology. Medical Microbiology is the advanced study of microorganisms important in human health and disease. For those students who have completed general microbiology immediately preceding Medical Microbiology the information should be fresh in the students' minds versus those students who

have waited several semesters to enroll in Medical Microbiology. Two students held positions in a laboratory prior to taking the Medical Microbiology course and laboratory. One student was a laboratory assistant responsible for general specimen processing including receiving and distribution. A second student had previously worked in a public health laboratory. The exact job description for the second student is unknown but being exposed to the language and techniques common in a lab may provide an advantage over the other students. Both of these students were included in the control group confounding the statistical analysis of the current study. The most important considerations for potential skewed results may reside in a student's inability or familiarity with web-based resources. A student who is comfortable with web-based tools would have been more likely to spend the allotted time on StudyMate than students who are not proficient with web-based tools.

Future Implementation

Institutions offer more online classes and degree programs each year; the convenience of scheduling and space appeal to both students and instructors alike. Research shows that there is no significant difference between face-to-face and online learning. Although this particular study failed to demonstrate significant improvement in student performance, the current literature does suggest that computer assisted instruction improves student performance. In fact, several researchers have shown that the best learning environments are blended or hybrid courses containing elements of face-to-face course work with computer assisted instruction. Blended courses offer benefits of both face-to-face and online courses. Posting introductory material online instead of lecturing opens valuable class time for discussion on more advanced topics. Looking to the future, a balance between convenience and improved student performance can be met by offering blended courses and degree programs.

Questions for Further Study

From the analysis of the Medical Microbiology students' learning styles it appears that a majority of students can be classified as reflective, sensing, visual, and sequential learners. It may be possible that making students aware of his or her individual learning style would allow them to convert material to his or her learning style preference. Further analysis of science majors is also warranted because large groups of individuals may be choosing not to be science majors because of the teaching methodologies common in the sciences, eliminating them on the basis of his or her learning style.

Based on statistical analysis it also appears that UWM students are less engaged than his or her peers. As stated earlier, student engagement is positively associated with student retention, student performance, and degree completion. Although the data are not shown first year students at UWM are also less engaged than his or her peers. Further analysis is required to determine how UWM as an institution can encourage student engagement through collaborative learning, faculty student interaction, and active learning.

REFERENCES

Allen, E., Walls, R., & Reilly, F. (2008). Effects of interactive instructional techniques in a web-based peripheral nervous system component for human anatomy. *Medical Teacher, 30*, 40-47.

Aragon, S. R., Johnson, S. D., & Shaik, N. (2002). The Influence of Learning Style Preferences on Student Success in Online Versus Face-to-Face Environments. *The American Journal of Distance Education*, 227-244.

Axelson, R., & Flick, A. (2011). Defining Student Engagement. *Change*, 38-43.

Carini, R., Kuh, G., & Klein, S. (2006). Student Engagement and Student Learning: Testing the Linkages. *Research in Higher Education*, 1-32.

Dictionary.com. (2012, October 18). Retrieved from Dictionary.com: www.dictionary.com

Dobson, J. (2010). A comparison between learning style preferences and sex, status, and course performance. *Advances in Physiology Education*, 197-204.

Felder, R. M. (1993). Reaching the Second Tier: Learning and teaching styles in college science education. *Journal of College Science Teaching*, 286-290.

Felder, R., & Spurlin, J. (2005). Applications, Reliability and Validity of the Index of Learning Styles . *International Journal of Engineering Education*, 103-112.

Fleming, N., & Mills, C. (1992). Not Another Inventory, Rather a Catalyst for Reflection. *To Improve the Academy*, 137-146.

Gardner, H. (1983). What is an intelligence? In *Frames of Mind: The Theory of Multiple Intelligence.* New York: Basic Books, A Member of the Perseus Books Group.

Gopal, T., Herron, S., Mohn, R., Hartsell, T., Jawor, J., & Blickenstaff, J. (2010). Effect of an interactive web-based instruction in the performance of undergraduate anatomy and physiology lab students. *Computers and Education, 55*(2), 500-512.

Graf, S., Viola, S. R., & Leo, T. (2007). In-Depth Analysis of the Felder-Silverman Learning Style Dimensions. *Journal of Research on Technology in Education*, 79-93.

Horton, D. M., Wiederman, S. D., & Saint, D. A. (2011). Assessment outcome is weakly correlated with lecture attendance: influence of learning style and use of alternative materials. *Advances in Physiology Education*, 108-115.

Kazmi, A. (2010). Sleep walking through Undergrad: Using Student Engagement as an Institutional Alarm Clock. *College Quarterly*, 1-15.

Litzinger, T. A., Ha, L. S., Wise, J. C., & Felder, R. (2007). A Psychometric Study of the Index of Learning Styles. *Journal of Engineering Education*, 309-319.

McFarlin, B. (2008). Hybrid lecture-online format increases student grades in an undergraduate exercise physiology course at a large urban university. *Advances in Physiology Education*, 86-91.

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, K. (2010). *Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies.* U.S. Department of Education, Office of Planning, Evaluation, and Policy Development-Policy and Program Studies Services.

Merriam, S. B., Caffarella, R. S., & Baumgartner, L. M. (2007). Intelligence and Aging. In *Learning in Adulthood* (pp. 359-390). San Francisco: John Wiley & Sons, Inc.

National Survey of Student Engagement. (2011). *Fostering Student Engagement Campuswide-Annual results 2011*. Bloomington, IN: Indiana University Center for Postsecondary Research.

Neuhauser, C. (2002). Learning style and effectiveness of Online and Face-to-Face Instruction. *The American Journal of Distance Education*, 99-113.

Palloff, R. M., & Pratt, K. (2007). *Building Online Learning Communities.* San Francisco: Jossey-Bass.

Romanell, F., Bird, E., & Ryan, M. (2009). Learning Styles: A Review of Theory, Application and Best Practices. *American Journal of Pharmaceutical Education*, 1-5.

Schuhmann, R., & Skopek, T. (2009). Blurring the Lines: A Blended Learning Model in a Graduate Public Administration Program. *The Quarterly Review of Distance Education* , 219-232.

Solomon, B., & Felder, R. M. (n.d.). *NC State Univerisity Index of Learning Styles*. Retrieved January 31, 2011, from Index of Learning Styles Questionnaire: http://www.engr.ncsu.edu/learningstyles/ilsweb.html

StudyMate Author Workshop. (2010, April 2). *Learning Technology Center*. University of Wisconsin-Milwaukee.

Svanum, S., & Bigatti, S. (2009). Academic Course Engagement During one Semester Forecasts College Success: Engaged Students are more like to earn a degree, do it faster, and do it better. *Journal of College Student Development*, 120-132.

Tanner, K., & Allen, D. (2004). Approaches to Biology Teaching and Learning: Learning Styles and the Problem of Instructional Selection--Engaging All Students in Science Courses. *The American Society for Cell Biology*, 197-201.

Vaughan, N. (2007). Perspectives on Blended Learning in Higher Education. *International Journal on E-learning*, 81-94.

Warner, R. M. (2008). *Applied Statistics: From Bivariate through Multivariate Techniques.* London: Sage Publications, Inc.

Wolf-Wendel, L., Ward, K., & Kinzie, J. (2009). A Tangled Web of Terms: The Overlap and Unique Contribution of Involvement, Engagement, and Integration to Understanding College Student Success. *Journal of College Student Development*, 407-428.

Appendix A:

Index of Learning Styles Survey

INDEX OF LEARNING STYLES*

DIRECTIONS
Enter your answers to every question on the ILS scoring sheet. Please choose only one answer for each question. If both “a” and “b” seem to apply to you, choose the one that applies more frequently.

1. I understand something better after I
   a. try it out.
   b. think it through.

2. I would rather be considered
   a. realistic.
   b. innovative.

3. When I think about what I did yesterday, I am most likely to get
   a. a picture.
   b. Words.

4. I tend to
   a. understand details of a subject but may be fuzzy about its overall structure.
   b. understand the overall structure but may be fuzzy about details.

5. When I am learning something new, it helps me to
   a. talk about it.
   b. think about it.

6. If I were a teacher, I would rather teach a course
   a. that deals with facts and real life situations.
   b. that deals with ideas and theories.

7. I prefer to get new information in
   a. pictures, diagrams, graphs, or maps.
   b. written directions or verbal information.

8. Once I understand
   a. all the parts, I understand the whole thing.
   b. the whole thing, I see how the parts fit.

9. In a study group working on difficult material, I am more likely to
   a. jump in and contribute ideas.
   b. sit back and listen.

10. I find it easier
    a. to learn facts.
    b. to learn concepts.

11. In a book with lots of pictures and charts, I am likely to
    a. look over the pictures and charts carefully.
    b. focus on the written text.

12. When I solve math problems
    a. I usually work my way to the solutions one step at a time.
    b. I often just see the solutions but then have to struggle to figure out the steps to get to them.

13. In classes I have taken
    a. I have usually gotten to know many of the students.
    b. I have rarely gotten to know many of the students.

14. In reading nonfiction, I prefer
    a. something that teaches me new facts or tells me how to do something.
    b. something that gives me new ideas to think about.

15. I like teachers
    a. who put a lot of diagrams on the board.
    b. who spend a lot of time explaining.

16. When I'm analyzing a story or a novel
    a. I think of the incidents and try to put them together to figure out the themes.
    b. I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.

17. When I start a homework problem, I am more likely to
    a. start working on the solution immediately.
    b. try to fully understand the problem first.

18. I prefer the idea of
    a. certainty.
    b. theory.

19. I remember best
    a. what I see.
    b. what I hear.

20. It is more important to me that an instructor
    a. lay out the material in clear sequential steps.
    b. give me an overall picture and relate the material to other subjects.

21. I prefer to study
    a. in a study group.
    b. alone.

22. I am more likely to be considered
    a. careful about the details of my work.
    b. creative about how to do my work.

23. When I get directions to a new place, I prefer
    a. a map.
    b. written instructions.

24. I learn
    a. at a fairly regular pace. If I study hard, I'll "get it."
    b. in fits and starts. I'll be totally confused and then suddenly it all "clicks."

25. I would rather first
    a. try things out.
    b. think about how I'm going to do it.

26. When I am reading for enjoyment, I like writers to
    a. clearly say what they mean.

    b. say things in creative, interesting ways.

27. When I see a diagram or sketch in class, I am most likely to remember
    a. the picture.
    b. what the instructor said about it.

28. When considering a body of information, I am more likely to
    a. focus on details and miss the big picture.
    b. try to understand the big picture before getting into the details.

29. I more easily remember
    a. something I have done.
    b. something I have thought a lot about.

30. When I have to perform a task, I prefer to
    a. master one way of doing it.
    b. come up with new ways of doing it.

31. When someone is showing me data, I prefer
    a. charts or graphs.
    b. text summarizing the results.

32. When writing a paper, I am more likely to
    a. work on (think about or write) the beginning of the paper and progress forward.
    b. work on (think about or write) different parts of the paper and then order them.

33. When I have to work on a group project, I first want to
    a. have "group brainstorming" where everyone contributes ideas.
    b. brainstorm individually and then come together as a group to compare ideas.

34. I consider it higher praise to call someone
    a. sensible.
    b. imaginative.

35. When I meet people at a party, I am more likely to remember
    a. what they looked like.
    b. what they said about themselves.

36. When I am learning a new subject, I prefer to
    a. stay focused on that subject, learning as much about it as I can.
    b. try to make connections between that subject and related subjects.

37. I am more likely to be considered
    a. outgoing.
    b. reserved.

38. I prefer courses that emphasize
    a. concrete material (facts, data).
    b. abstract material (concepts, theories).

39. For entertainment, I would rather
    a. watch television.
    b. read a book.

40. Some teachers start his or her lectures with an outline of what they will cover. Such outlines are
    a. somewhat helpful to me.
    b. very helpful to me.

41. The idea of doing homework in groups, with one grade for the entire group,
    a. appeals to me.
    b. does not appeal to me.

42. When I am doing long calculations,
    a. I tend to repeat all my steps and check my work carefully.
    b. I find checking my work tiresome and have to force myself to do it.
43. I tend to picture places I have been
    a. easily and fairly accurately.
    b. with difficulty and without much detail.

44. When solving problems in a group, I would be more likely to
    a. think of the steps in the solution process.
    b. think of possible consequences or applications of the solution in a wide range of areas.

ILS Scoring Sheet

1. Put "1"s in the appropriate spaces in the table below (e.g. if you answered "a" to Question 3, put a "1" in Column A by Question 3).

2. Total the columns and write the totals in the indicated spaces.

3. For each of the four scales, subtract the smaller total from the larger one. Write the difference (1 to 11) and the letter (a or b) for which the total was larger on the bottom line.

    For example, if under "ACT/REF" you had 4 "a" and 7 "b" responses, you would write "3b" on the bottom line under that heading

4. On the next page, mark "X"s above your scores on each of the four scales.

ACT/REF			SENS/INT			VIS/VRB			SEQ/GLO		
Q	a	b	Q	a	b	Q	a	b	Q	a	b
1	_____	_____	2	_____	_____	3	_____	_____	4	_____	_____
5	_____	_____	6	_____	_____	7	_____	_____	8	_____	_____
9	_____	_____	10	____	_____	11	____	_____	12	____	_____
13	____	_____	14	____	_____	15	____	_____	16	____	_____
17	____	_____	18	____	_____	19	____	_____	20	____	_____
21	____	_____	22	____	_____	23	____	_____	24	____	_____
25	____	_____	26	____	_____	27	____	_____	28	____	_____
29	____	_____	30	____	_____	31	____	_____	32	____	_____
33	____	_____	34	____	_____	35	____	_____	36	____	_____
37	____	_____	38	____	_____	39	____	_____	40	____	_____
41	____	_____	42	____	_____	43	____	_____	44	____	_____
Total (sum X's in each column)											
ACT/REF			SENS/INT			VIS/VRB			SEQ/GLO		
	a _____	b_____		a _____	b_____		a _____	b_____		a _____	b_____
(Larger –Smaller) + Letter of Larger											

Example: If you totaled 3 for a and 8 for b, you would enter 5b in the space below.

Transfer your scores to the ILS report form by placing X's at the appropriate locations on the four scales.

ILS Report Form

ACT_______________________________|_______________________________REF
11a 9a 7a 5a 3a 1a | 1b 3b 5b 7b 9b 11b

SEN_______________________________|_______________________________INT
11a 9a 7a 5a 3a 1a | 1b 3b 5b 7b 9b 11b

VIS_______________________________|_______________________________VRB
11a 9a 7a 5a 3a 1a | 1b 3b 5b 7b 9b 11b

SEQ_______________________________|_______________________________GLO
11a 9a 7a 5a 3a 1a | 1b 3b 5b 7b 9b 11b

If your score on a scale is 1-3, you are fairly well balanced on the two dimensions of that scale.

If your score on a scale is 5 or 7, you have a moderate preference for one dimension of the scale and will learn more easily in a teaching environment which favors that dimension.

If your score on a scale is 9 or 11, you have a very strong preference for one dimension of the scale. You may have real difficulty learning in an environment which does not support that preference.

Appendix B:

Student Engagement Survey

Student Engagement Survey
Medical Microbiology 2011

The objective of this survey is to assess your current level of student engagement. Your name is required to correlate data. All information will be kept confidential and used for research purposes only. Your responses will not affect your grade.

In your experience, how often in the previous semester have you done the following? Mark your response with an X.

		Very Often	Often	Sometimes	Never
Cooperation with peers	Worked with other students on a project outside of class				
	Studied with other students				
	Asked your peers to read something you have written to make sure your ideas are clear				
	Participated in a student organization (student government, fraternities, sororities, intramural sports, etc.)				
Active Learning	Asked questions or contributed to class discussion				
	Come to class without completing assignments				
	Constructed your own outline, diagram, flashcards, etc. from lecture notes or class readings				
	Revised a paper two or more times before handing the assignment in				
Faculty-student interaction	Made use of instructor or TA office hours				
	Worked with a faculty member on a research project				
	Discussed grades or assignments with an instructor				
	Discussed career plans or continuing education (master's, doctorate) with a faculty member				

How many semesters of school have you completed?___________________________________

How many semesters have you enrolled as a part-time student?_________________________

Are you a second-degree student (i.e. do you already have a Bachelor's degree)?
____

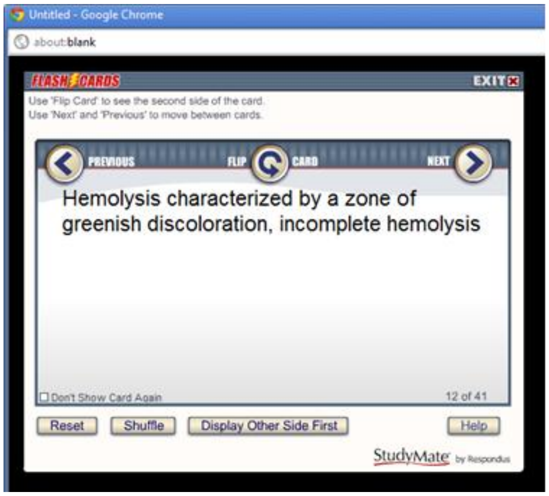
Please list extra-curricular activities that you participate in (student government, fraternities, sororities, intramural sports, etc.)
____
____
____
____

How many hours in a week do you spend on the following?

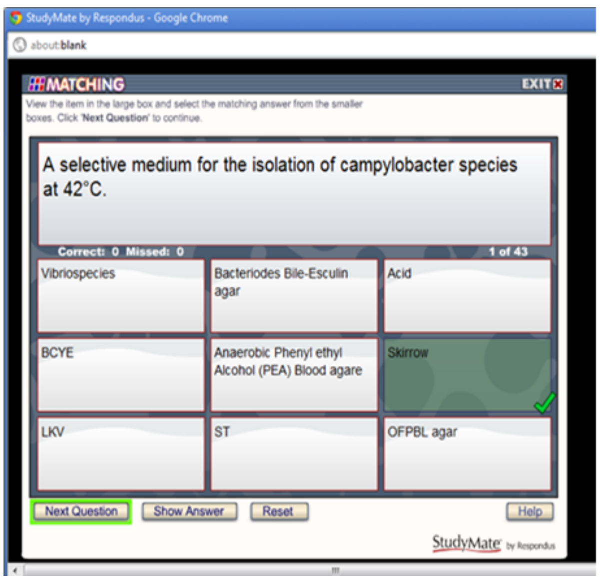
ITEM	HOURS per week
Preparing for class (for a 12-18 credit course load)	
Work on campus	
Work off campus	
Commuting to class	
Relaxing and socializing outside of class	
Caring for a spouse, child, parent, or dependent	
Participating in extra-curricular activities	

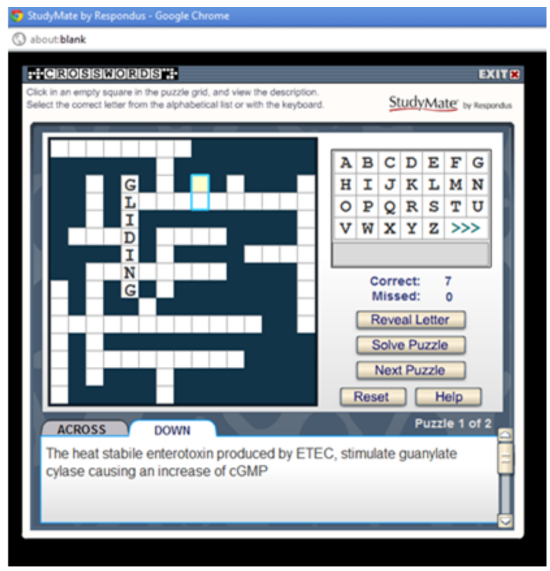
Appendix C:

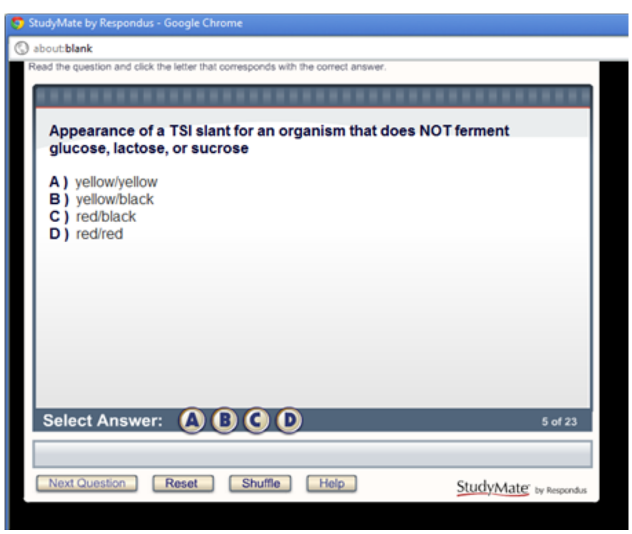
StudyMate Screen Shots


Untitled - Google Chrome
about:blank
FLASH CARDS
EXIT
Use 'Flip Card' to see the second side of the card.
Use 'Next' and 'Previous' to move between cards.
PREVIOUS
FLIP CARD
NEXT
Hemolysis characterized by a zone of greenish discoloration, incomplete hemolysis
Don't Show Card Again
12 of 41
Reset
Shuffle
Display Other Side First
Help
StudyMate by Respondus


StudyMate by Respondus - Google Chrome
about:blank
FLASH CARDS
EXIT
Use 'Flip Card' to see the second side of the card.
Use 'Next' and 'Previous' to move between cards.
PREVIOUS
FLIP CARD
NEXT
Alpha
Don't Show Card Again
12 of 41
Reset
Shuffle
Display Other Side First
Help
StudyMate by Respondus


StudyMate by Respondus - Google Chrome
about:blank
MATCHING
EXIT
View the item in the large box and select the matching answer from the smaller boxes. Click 'Next Question' to continue.
A selective medium for the isolation of campylobacter species at 42°C.
Correct: 0 Missed: 0
1 of 43
Vibriospecies
Bacteriodes Bile-Esculin agar
Acid
BCYE
Anaerobic Phenyl ethyl Alcohol (PEA) Blood agare
Skirrow
LKV
ST
OFPBL agar
Next Question
Show Answer
Reset
Help
StudyMate by Respondus


StudyMate by Respondus - Google Chrome
about:blank
CROSSWORDS
EXIT
Click in an empty square in the puzzle grid, and view the description.
Select the correct letter from the alphabetical list or with the keyboard.
StudyMate by Respondus
A B C D E F G
H I J K L M N
O P Q R S T U
V W X Y Z >>>
Correct: 7
Missed: 0
Reveal Letter
Solve Puzzle
Next Puzzle
Reset
Help
ACROSS
DOWN
Puzzle 1 of 2
The heat stabile enterotoxin produced by ETEC, stimulate guanylate cylase causing an increase of cGMP


StudyMate by Respondus - Google Chrome
about:blank
Read the question and click the letter that corresponds with the correct answer.
Appearance of a TSI slant for an organism that does NOT ferment glucose, lactose, or sucrose
A) yellow/yellow
B) yellow/black
C) red/black
D) red/red
Select Answer: A B C D
5 of 23
Next Question
Reset
Shuffle
Help
StudyMate by Respondus