MEASURING THE EFFECTS OF CLASS SCHEDULING ON STUDENT SUCCESS IN SECODARY SCHOOL CHEMISTRY USING CONTENT-BASED VERSUS LOGICAL THINKING-BASED ONLINE COMMERCIAL PROGRAMS

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ABSTRACT

The guiding question of every educational decision is supposed to be "What is best for the student?" Many secondary schools have experimented with a variety of class scheduling patterns in an effort to maximize teacher expertise as well as student time and access to courses mostly relying on anecdotal data to support decisions. Schools entering the 21st century often turned to the use of technology as a method to ensure student achievement. This study evaluated the effectiveness of two commercially available online programs. An online chemistry content-drill program, Study Island©, and a Web-based program aiming to improve logical-thinking skills, Lumosity™, were considered in this research. These Information and Communication Technology (ICT) programs were evaluated based on pre- and post-test scores of 74 pre-Advance Placement (pre-AP) chemistry students on the American Chemical Society's California Chemistry Diagnostic Exam (CA Dx). Also, reported are the results of the effect of class scheduling versus student achievement on the CA Dx exam after experiencing these brain-training programs. *[AJCE 4(3), Special Issue, May 2014]*

INTRODUCTION

Learning is a continuous process that is built upon prior knowledge and results in an increased understanding of the subject in question. Instruction in chemistry usually stresses the importance of linking prior knowledge with new information learned in a classroom [1]. According to Edelson [2], knowledge is not transmitted to others equally; results vary depending upon the learner's prior knowledge and experiences, and desired "rich knowledge" is not constructed instantaneously rather it is created in incremental steps where understanding is gained. There are numerous commercial training interventions claiming to improve general mental capacity and there is a "widely held belief that commercially available computerized brain-training programs improve general cognitive function in the wider population" but the lack of empirical support for these claims is sparse [3-4].

The one-on-one direct learning mode of a computer incorporates the three basic learning styles (visual, auditory and tactile) with auditory and visualization outputs and physical manipulations together in a single educational event. According to a study published by Schoenfeld-Tacher, McConnell, and Graham, students tend to be more apt to be on-task and consequently have a greater chance of success when experiencing online instruction as compared to the traditional classroom presentation [5]. Since Web-based instruction has advanced to the point that asynchronous learning (even within the timeframe of a single class period) is easily accessible, it is now time to evaluate the most effective use of typical online lecture material and complementary support material along with how it is delivered to students.

This study was designed to compare the effects of different types of online practice (either logical thinking skills or supplemental content drill and practice) on student achievement completed by pre-Advance Placement (pre-AP) chemistry students whose classes met on similar

and different schedules. Academic gains were measured by evaluating the changes in student scores on the American Chemical Society's California Diagnostic Exam (CA Dx) Form 1997.

Tools for Information and Communication Technologies (ICT)

Cooper presented the following observations about doing homework: positive effects include content retention, better comprehension of concepts, extended problem-solving practice with improved training of habits, bettered attitudes dealing with self-discipline, and improved curiosity and independence; negative effects include perceived fatigue and pressure, identified confusion, increased cheating, and potential loss of interest [6]. Difficulties implementing ICT in the classroom also include mechanical issues [7] as well as lack of congruence with teachers' instructional practices and philosophies [8].

Success may depend on how instructors perceive the use of ICT before they begin implementation, because most teachers require proof of student success before they implement a new pedagogy in their classrooms. Similar observations as noted above about doing homework can also be made of using ICT in the classroom. Online learning in and of itself creates an environment where students are required to be participating in an interactive environment. Being on-task translates to being engaged with the subject matter that encourages increased time-on-task. Instantaneous feedback respects where the student is and where the instructor wishes to take them on an individual basis, but as always, what is learned is up to the one that partakes [9].

Online intervention via some sort of "brain training" is one way to meet the needs of students on an individual basis. Immediate feedback dominates why ICT are so advantageous to students' understanding and have been proven to show great promise. The employment of tools supporting ICT when used appropriately also allow the instructor more time to work on the areas

of critical need during the class. Numerous studies have shown that immediate feedback boosts the confidence of students [9]. Epstein, Epstein and Brosvic [10] demonstrated that immediate feedback on academic testing increased retention and confidence levels of students. Also from other studies, lower-achieving students tended to be more apt to stay in classes, as opposed to dropping or withdrawing, if they have the added support of online homework [11-12].

Brain Training

Providing evidence for the effectiveness of cognitive (often called "brain") training is a current research area in need of empirical support. Cognitive training can be effective and long lasting. However, there are limiting factors that must be considered when evaluating the effects of this training, including individual differences in training performance and the effect of external variables such as of the frequency and duration of contact [4].

In this study, two commercial online systems were compared to evaluate of what type of brain-training, logical thinking or content skill building, is better for improving student achievement. The online brain-training programs used in this study were Study Island© (studyisland.com) and Lumosity™ (lumosity.com) (Fig. 1). Study Island© was chosen to enhance students' content knowledge and Lumosity™ was chosen to contribute to improving students' logical-thinking ability both attributes considered to be important to student success in the study of chemistry.

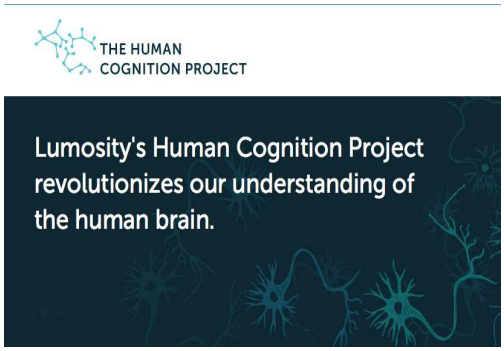

Figure 1. Logos for brain-training programs used in this study Lumosity™ and Study Island©.

Overview of Setting and Sample Population

The societal changes of the 1960s in the United States brought radical changes to the educational system and many felt that emphasizing schoolwork outside of the school day actually neglected other areas of personal fulfillment [6]. By 1980, technology had begun to advance rapidly and the public saw a need for greater educational standards and favored teachers assigning homework [13]. Online homework is known to increase overall student success by at least a letter grade when student master their assignments at the 90% or higher level [14].

In this study, the brain-training programs (logos seen in Fig. 1) were used to enhance student achievement at a high school in north central Texas (Fig. 2). Denton, Texas (population of 1.24 million) is home to two universities (Texas Woman's University and the University of North Texas) and three schools for students attending grades 9-12. The students chosen for this study attended one of the local secondary schools with a population of around 2,000. Forty-two percent of the students were White, non-Hispanic. The largest ethnic group was that of Hispanic students composing approximately 37% of the total population. The remaining ethnic groups were 12% African American, 8% Asian, and 1% classified as other (which includes Native Americans and blended ethnicities). Almost half of the students (42%) received free and/or

reduced cost meals on campus. This percentage is an indicator of the portion of students from low-income families. The participants chosen for this study were enrolled in pre-advanced placement (pre-AP) chemistry classes in grades 9-11 and were of ages 14-16 years. For the treatment intervention, the pre-AP chemistry students completed 45-minutes per week of class time (no time outside of class) of online brain training from the two chosen online programs: Study Island© or Lumosity™.

Figure 2. Location of Denton, Texas, USA.

METHODOLOGY

High school educators have several situations to balance as they plan instruction for their students. Traditionally, high school classes are scheduled to meet five days a week for 55 minutes. Some schools opt to use block scheduling to mimic a more typical class schedule encountered in college, where classes do not typically meet daily. In a block schedule, students meet for specific classes every other day for 90 minutes. Class schedules and assignment of each student are imposed by school administration (see Table 1). Data for this study were gathered over the 2011-2012 academic school year for the 74 students evaluated.

Table 1. Study Group Descriptions (n = 74)

Groups	Class Schedule	Brain-Training Event	Number Students	Gender
D55L	55 Minute Block Meets Every Day	Logical-thinking Skills	27	52% female
A90L	90 Minute Block Meets Every Other Day	Logical-thinking Skills	26	42% female
A90C	90 Minute Block Meets Every Other Day	Content Skill Building	21	67% female

Abbreviations for Groups: D = daily; A = alternating days; L = logical skill; C = content skill

Research Questions

Student achievement in this study was measured by success on the American Chemical Society Division of Chemical Education's California Diagnostic Exam (1997) (CA Dx) that has a national mean (SD) of 20.45 (7.56). Students were given the CA Dx exam as a pre/post assessment at the beginning and end of the study.

1. What are the differences in student achievement on the California Diagnostic Exam when students meet every day and used Lumosity™ or every other day and used Lumosity™?
2. What are the differences in student achievement on the California Diagnostic Exam when students have similar schedules meeting every other day and experience different brain-training programs of Study Island© or Lumosity™?
3. What are the differences in student achievement on the California Diagnostic Exam independent of the class scheduled meeting times when students used either Study Island© or Lumosity™?

Instrumentation: Study Island©, Lumosity™ and California Diagnostic Exam

While classroom teachers are not able to dictate the schedule chosen for a school, they do have the option of determining the type of instructional tools that can be used in the classroom.

Chemistry is a course that requires students to develop logical-thinking and reasoning skills as they learn about chemical principles. Therefore, it would stand to reason that practice problems designed to help students develop their logical-thinking skills would also help them to be successful in learning chemistry. As previously discussed there are online programs designed with the emphasis on chemistry concepts as well as programs with an emphasis on logical-thinking skills appropriate for students in grades 9-12.

Attending to academic tasks is one of the most important aspects of learning according to the Unified Learning Model (ULM) of Shell et al. [13]. Lumosity™ is part of the Human Cognition Project. Researchers from Lumos Labs published the first-ever study demonstrating that normal, healthy adults could use online cognitive training to enhance memory and attention [15]. According to data published in the *Mensa Research Journal*, participants who trained 20 minutes a day for 5 weeks saw an approximate 10% improvement in working memory and approximately 20% improvement in visual attention. The control participants who did not train did not improve [15].

Study Island© is an online program intended for use in USA secondary classrooms. "Study Island is a leading academic software provider of standards-based assessment, instruction, and test preparation e-learning programs." [16]. Study Island© presents interactive lessons that are personalized for each student guiding them through the intended curriculum (in this case for first-year chemistry at the secondary school level) at their own pace. The training content is intended to prepare students for the end-of-course exam in chemistry.

The California Diagnostic Exam (CA Dx) is a 44-question multiple-choice exam designed to evaluate chemistry content knowledge. The CA Dx was administered to each of the participating sections on two separate occasions. The test was administered prior to completion

of any online practice to evaluate the amount of prior content knowledge of the students. The second administration of the test was given at the end of the term to evaluate any changed in student content knowledge.

RESULTS AND DISCUSSION

Data Analysis

The scores for the CA Dx were recorded as the number of correct responses out of 44 questions for each student on both the pretest and the repeated posttest. The mean pre- and post-test scores for each group are compiled onto Table 2. The following groups were evaluated to determine if statistically significant differences were present at the .05 level: same program with different schedules, same schedules with different programs, and comparison of the two programs overall. Levene's test for homogeneity of variance was used to evaluate the difference in variances of scores between groups and the independent samples student *t*-test used to compare the mean score of each group. The Levene's test and independent samples student *t*-test should not produce statistically significant results on the pretest because all students participating in the study are from the same population. The posttest values for these tests should be statistically different for comparisons in which the treatment has had an impact on student performance.

Table 2. Raw Score Data for Pre/Post California Diagnostic Exam Results (n =74)

Brain-Training Treatment Groups*	**Pre-Test Mean (SD)**	**Post-Test Mean (SD)**	**Change in Raw Score**
D55L: Logical Thinking Meets Every Day	15.19 (5.70)	23.52 (7.11)	8.33
A90L: Logical Thinking Meets Every Other Day	14.08 (4.19)	17.15 (7.21)	3.07
A90C: Content Drill Meets Every Other Day	12.90 (5.38)	18.42 (5.09)	5.52

*Abbreviations for Groups: D = daily; A = alternating days; L = logical skill; C = content skill

Same Program and Different Schedules

Student performance on the pre- and post-tests was compared for students who completed the brain-training program highlighting skills emphasizing logical thinking (Lumosity™) on different schedules. For this intervention students enrolled in sections that met for different lengths of time and frequencies were evaluated. Data from Table 2 indicate that the students who were in the class that met every day and received the logical-thinking treatment outperformed the other student group that attended class every other day and used the same program. This may indicate that students who received frequent, smaller increments of instruction have an advantage over instruction that is less frequent. On the average both groups improved on the posttest with the daily group exhibiting a larger increase: student improvement by approximately 8 questions for group D55L and by approximately 3 questions for group A90L. The difference in student performance for these groups was evaluated with Levene's test of homogeneity of variance and independent samples student *t*-test at the .05 level. These results are reported in Table 3.

Table 3. Independent Samples *t*-Tests Comparing Groups who used the Same Program under Different Schedules (n = 74)

D55L vs. A90L*	**Levene's Test of Homogeneity**		***t*-Test for Equality of Means**
	F	**Sig.**	**Sig. (Two-tailed)**
Pretest	1.596	0.212	0.425
Posttest	0.087	0.770	0.002

*D55L = Meets daily for 55 min. and used Lumosity;
A90L = Alternating days for 90 min. and used Lumosity

The difference in student performance on the pretest was not statistically significant that indicates that the two samples were equivalent at the beginning of the study (see Table 3). The

Levene's test of homogeneity was not statistically significant for the posttest scores but the independent samples *t*-test for equality of means was statistically significant. The difference in the distribution of the scores was not statistically significant, but the difference in average student performance across both groups was statistically significant. On average the section that met daily for a shorter period of time performed better on the posttest than the section that met less frequently for a longer interval by approximately 5 questions.

Different Program with Same Type Schedule

Student performance on the pre- and post-tests was compared for students who completed different brain-training programs and met for the same length of time and frequency. The overall performance of these groups is reported in Table 4. The difference in student performance for these groups was evaluated with Levene's test of homogeneity of variance and independent samples student *t*-test at the .05 level. These results are reported in Table 5. Neither the pretest or posttest scores showed statistically significant differences between the groups of students with similar meeting schedules.

Table 4. Raw Score Data for Students Meeting Every Other Day and Using Different Brain-training Programs (n = 74)

Brain-Training Treatment Groups*	Pretest Mean (SD)	Posttest Mean (SD)	Change in Raw Score
A90L: Logical Thinking Meets Every Other Day	14.08 (4.19)	17.15 (7.21)	3.07
A90C: Content Drill Meets Every Other Day	12.90 (5.38)	18.42 (5.09)	5.52

*A90L = Alternating days for 90 min., used Lumosity™;
A90C = Alternating days for 90 min., used Study Island©

Logical-thinking brain-training group (A90L) had approximately a 3-question improvement on the posttest score compared to the pretest score. The content-drill brain-training

group (A90C) had approximately a 6-question improvement on the posttest score compared to the pretest score. The difference in mean student performance was not statistically significant for the pre- and post-tests. Additionally, the Levene's test of homogeneity was not statistically significant for the distribution of either set of scores (see Table 5). Overall, the average scores and distribution of scores for the groups with the same meeting schedule (A90L and A90C) were not statistically different from each other despite receiving different brain-training events.

Table 5. Independent Samples *t*-Tests Comparing Groups who Used Different Brain-training Programs Under Similar Schedules (n = 74)

A90L vs. A90C	**Levene's Test of Homogeneity**		***t*-Test for Equality of Means**
	F	**Sig.**	**Sig. (Two-tailed)**
Pretest	0.054	0.817	0.405
Posttest	1.914	0.173	0.564

*A90L = Alternate days for 90 min., used Lumosity™;
A90C = Alternate days for 90 min., used Study Island©

Different Programs and Different-type Schedule

The two groups that participated in the brain-training program designed to improve logical-thinking abilities (D55L and A90L) did not exhibit a statistically significant difference on the pretest (see Table 3). These two groups were combined to evaluate the difference in student performance based on participation in the different brain-training programs (logical-thinking vs. content drill and practice) independent of the frequency and duration of class meetings. The overall performance of these groups is reported in Table 6.

Table 6. Raw Score Data for Students in Different Brain-Training Groups (n = 74)

Brain-Training Treatment Groups*	Pre-Test Mean (SD)	Post-Test Mean (SD)	Change in Raw Score
D55L & **A90L**: Logical Thinking	14.65 (5.00)	20.40 (7.78)	5.75
A90C: Content Drill	12.90 (5.38)	18.42 (5.09)	5.34

*D55L and A90L = had different scheduled times and frequency and both used Lumosity™; A90C = Alternating days for 90 min., used Study Island©

Brain-training groups (D55L and A90L) that experienced logical-thinking skill practice had approximately a 6-question improvement from the pretest score to the posttest. The brain-training group that practiced content (A90C) had a 5-question improvement from the pre- to post-test score. The difference in student performance for these groups on the pre- and post-tests was evaluated with Levene's test of homogeneity of variance and independent samples student *t*-test at the .05 level. These results are reported in Table 7.

Table 7. Independent Samples *t*-Tests Comparing Different Treatments Independent of Schedule (n = 74)

D55L & A90L vs. A90C	Levene's Test of Homogeneity		*t*-Test for Equality of Means
	F	Sig.	Sig. (Two-tailed)
Pretest	0.151	0.699	0.192
Posttest	3.602	0.062	0.245

When the students are grouped based on the brain-training program used in class, there was not a statistically significant difference in the means or the variance of the scores on the pre- and post-tests at the .05 level. This supports the results in Table 5, which also shows that there is

not a statistically significant difference in student performance based on the program used for instruction.

Limitations

The scheduling and class assignments for this study were determined by the school's administrators, not the researchers. It would have been ideal to have a group of students in the content-training group that had met every day but the nature of the school class assignment system did not allow for this addition to the study. Future trials for this study will not be available using the same content drill brain-training program. Sapling Learning© (saplinglearning.com) will replace Study Island© as the content drill brain training program in future trials.

CONCLUSIONS

Impact of Scheduling on Student Success (Research Question 1)

The impact of scheduling on student performance when the same brain-training program was assigned was determined by evaluating the difference in student performance on the pre- and post-test for the two groups who participated in the logical-thinking brain-training program, D55L and A90L. The change in the mean raw score was approximately 8 questions for group D55L and approximately 3 questions for group A90L. The variance and mean of the scores between these two groups were not statistically significant on the pretest. The difference in the variance of the scores on the posttest was not statistically significant. However, the difference in the mean scores between these two groups on the posttest was statistically significant even though the overall distribution of scores across the two groups remained homogeneous.

Additionally, the statistically significant difference in the mean scores on the posttest indicates that the section that met more frequently for a shorter duration, D55L, was more beneficial for student learning.

Impact of Brain-Training Programs on Student Success

Same Meeting Schedule (Research Question 2)

The impact of the brain-training programs on student performance, when students were assigned to sections that met for the same duration and frequency, was determined by evaluating the difference in student performance on the pretest and posttest for the two groups that met for 90 minutes every other day, A90L and A90C. The differences in the mean and variance of the scores between these two groups were not statistically significant for either the pretest or the posttest. The overall distribution of scores across the two groups remained homogeneous and the different brain-training programs did not produce a statistically significant difference in student performance.

Independent of Meeting Schedule (Research Question 3)

The performance of the two groups that participated in the logical-thinking brain-training program, D55L and A90L, were combined and compared with the performance of the group that participated in the content drill brain-training program, A90C. This analysis was completed to further investigate the finding that the brain-training programs did not produce a statistically significant difference in student performance. The differences in the mean and variance of the scores between these two groups were not statistically significant for either the pretest or the posttest, confirming the results found in the previous analysis [17].

The duration and frequency of instruction influenced the progress of students' performance on the content assessment. Based on current data, there is not a statistically significant difference in the two types of interventions. Therefore, duration and frequency of instruction were influential on student performance and the type of brain-training program used during instructional time did not show a significant impact.

Future Recommendations

The ULM promotes three components that underlie student learning and e-instruction: (1) **prior knowledge** is the most predictive element that determines students' success in their current courses; (2) **engagement** with the course's subject matter is also very important to success because if students do not attend to the material that is required to succeed, they will miss important information that will limit their success; and (3) **motivation** that is the driving force behind how students attend to the subject matter [13]. Mastery of online content has previously been defined as correctly completing 90% or more of the expected content [14, 18].

We propose that future research should not only investigate whether cognitive-training works, but also should determine what training regimens and what training conditions result in the best transfer effects, investigate the underlying neural and cognitive mechanisms, and finally, investigate for whom cognitive training is most useful.

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