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The Impact of Study Strategies on Academic Performance for Medical Students at Wright State University

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THE IMPACT OF STUDY STRATEGIES ON ACADEMIC PERFORMANCE FOR MEDICAL STUDENTS AT WRIGHT STATE UNIVERSITY

A thesis submitted in partial fulfillment of the

requirements for the degree of Master of Science

By

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY **Markia Black,** ENTITLED **The Impact of Study Strategies on Academic Performance for Medical Students at Wright State University** BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF **Master of Science**.

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ABSTRACT

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Studying plays an important role in the academic success of medical students. It is likely that ineffective study skills result in poor performances on required standardized exams. There is a concern for the lack of empirical data related to what study strategies are the most productive for medical students to practice. My goal is to 1) identify what study strategies students use in their pre-clinical years of medical school, 2) determine if these strategies impact students' performance on

Comprehensive Basic Science Exams and Step 1 exam, and 3) identify study methods that best support student achievement in the pre-clinical phase of medical school. I will be providing the Boonshoft School of Medicine with the first analysis of student's performance relative to self-reported study habits since the reformation of the curriculum in 2017, using data from the graduating class of 2021. Furthermore, these results will contribute to biological education by identifying optimal study methods for academic achievement in the pre-clinical phase of medical school. In July of 2017, the incoming class of first year students (graduating class of 2021) at Wright State

University's Boonshoft School of Medicine (120 students) were given a survey at the beginning of medical school (August of 2017) to evaluate their study habits.

In this study, I examined the relationship between the self-reported study strategies and the students' academic performances measured by their success on the following standardized exams: Comprehensive Basic Science Exam 1 (CBSE1), Comprehensive Basic Science Exam 2 (CBSE2) distributed by the National Board of Medical Examiners (NBME), and the Step 1 Exam, distributed by United States Medical Licensure Examiners (USMLE). Results showed students preferred reviewing notes 27% of the time on average. Second to this, students preferred self-quizzing 14% of the time on average. Students also relied on explaining to self or others 12% of time on average and highlighting and creating concept maps were used 11% of time on average. Students that spent more time using contextualization practices defined by the use of concept mapping, self-quizzing, and explaining performed better on the Step 1 exam (p value $< .05$). Deep learning practices like contextualization require cognitive effort and do not focus on rote memorization techniques that require little cognitive work (Gettinger and Seibert 2002). Deep processing strategies anchor the information into the memory based on the cognitive challenges while surface strategies do not (Brown et al. 2014). Therefore, it was predictable to see no relationship between the surface processing practices and increased Step 1 scores. In addition to this, contextualization showed a positive trend in the CBSE gain. This relationship was not as strong as the correlation between use of contextualization and Step 1 scores. Results from an Exploratory Factor Analysis in my study suggest students use a collective of deep processing strategies with an emphasis on contextualization to achieve greater learning outcomes and increase scores on the USMLE Step 1 exam. Further investigations on study strategies and how they impact student success will aid in increasing academic achievement.

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I. INTRODUCTION

OVERVIEW

Studying is a task that learners need to master early on. Instructors are clear that students should study to achieve success but lack clarity in how students should study. Conversely, many times the question of how to study has gone without being asked and has therefore been left unanswered. Yet, effective study plans and skills are critical tools for learning (Jato et al. 2014, Mendezabal 2013., Gettinger and Seibert 2002).

A strategy is a plan of action that is employed to reach a desired goal. A study strategy is a term that describes techniques within a plan or approach used to reach a desired learning goal. In reference to Bloom's taxonomy, the desired learning outcome is usually to reach a higher level of understanding associated with increasing levels of complexity and cognitive effort reflected by a student's ability to understand, apply, analyze, and independently build broader connections. The revised version by Anderson and Krathwohl (2001) revealed that study strategies students rely on would place students on the lowest tier of the hierarchical learning model because those strategies do not require students to comprehend or practice higher order thinking. Evidence of this is commonly seen because often learners can repeat information but do not understand much of it, if any at all.

Examples of study strategies used are re-reading and highlighting material, creating concept maps, self-quizzing, use of flashcards, replaying material, and even cramming. Academic competence depends on proper study techniques being incorporated into students' study plans (Kornell and Bjork 2007, Gettinger and Seibert 2002). Effective study routines include a variety of strategies that students use to reach their learning goals. It is understood that an adequate study strategy for one individual may not be the same for another. Also, a suitable study strategy for one task may not be fitting for another task. The goal is to provide an academic scaffold for study routines that will guide individuals to use optimal methods that yield the best performance results.

Professors might assume that by the time students begin college, they have metacognitive awareness and a history of adequate study planning that optimizes learning outcomes and performance (Yonker 2011). Many medical students do not adopt appropriate study strategies throughout their academic career due to lack of education on productive routines. The defective study approaches medical students use can lead to substandard performances on major medical exams (Gettinger and Siebert 2002, Tooth 1989). This warrants further research on study techniques that foster effective learning outcomes and academic achievement. There is a need to educate students on how to develop their study approach. The discrepancy in the relationship between studying and academic performance stems from the conditioned belief that learning comes from repeated exposure to material until it is mastered (Brown et al. 2014, Karpicke 2009, Ward and Walker 2008). The common sentiment that practice makes perfect is misleading when the type of practice is surface level and provides a superficial understanding of the material. The misconception that mastery is achieved when the content can be repeated closely to the way in which it was presented gives a feeling of false understanding (Brown et al.2014, Carey 2010, Ward and Walker 2008).

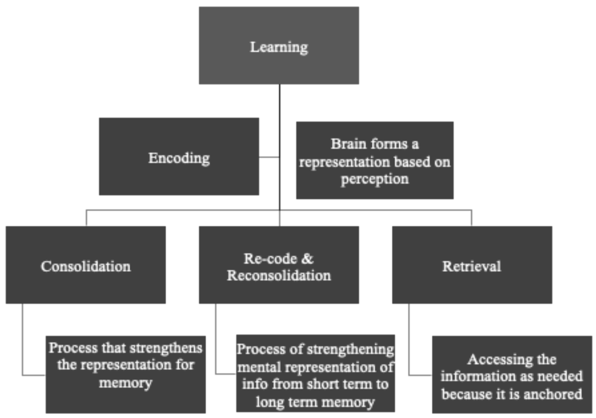

Figure 1. The cognitive process of how learning occurs based on *Make it Stick* by

Ward and Walker (2014).

Although it is not fully understood, it is important to discuss what is known thus far about the process of how learning occurs. When we talk about learning, we mean the act of acquiring knowledge and skills to have readily available in our memory and accessible based on our need. From what we do understand, learning starts with encoding. The brain encodes an individual's perception of information by transferring it into chemical and electrical phenomena. Next, the information is converted into memorable representations that are meaningful to the individual. After this, consolidation occurs. Consolidation is the period when representations of the context are reorganized, strengthened, and prepared for long-term memory. The period of consolidation ranges from several hours to days. In this time, the brain is replaying the information and building connections by merging what is being learned with prior knowledge and experiences (Brown et al. 2014).

After the lapse in time from the initial consolidation phase, the brain recodes and enters into another round of the consolidation phase. By doing this, the brain can anchor the information into memory. Once the information is secured in long-term memory, retrieval happens. Retrieval is the final step in the learning process and can be described as the act of recalling content from memory. Overall, the process of learning has been compared to crafting an essay because there are many versions of an essay created before reaching a final version (Brown et al. 2014).

In large, there is a common misunderstanding on what study strategies are beneficial to academic success. Since we often believe study routines that include rote learning strategies are impactful to learning and performance, popular study techniques such as massed practice and repetition are seemingly the best ways to master material. Students are accustomed to these types of practices and rely on them when they study for important exams such as the National Board of Medical Examiners (NBME), Comprehensive Basic Science Examination (CBSE), United States Medical Licensure Examination (USMLE) Step 1 exam, and even the Association of American Medical Colleges (AAMC) Medical College Admission Test (MCAT). Qualitative research studies are beginning to challenge the views on conventional study strategies by strongly arguing that they produce a pseudo-understanding of material and poor test results. Questions arise on what study strategies are truly productive for learning and success.

Many study routines practiced by student are counterproductive or have little to no benefit toward their learning (Brown et al. 2014, Carey 2010, Gettinger and Seibert 2002). These practice routines include tactics such as re-reading material, highlighting text, and repetition, all of which produce limited levels of cognition, productivity, and low levels of academic performance. (McCabe 2018, Brown et al. 2014, Carey 2010, McDaniel and Callender 2009, Gettinger and Siebert 2002). This includes performances on licensure examinations as well (Mendezabal 2013). These methods are classified as surface processing methods. An example of this is the pervasive belief that learning by massed practice (surface processing strategies) leads to a promising outcome across all subject matter (Brown et al. 2014). Empirical evidence strongly supports a counterclaim, stating the most productive learning strategies are counterintuitive and require students to face challenges rather than the single study method of massed practice such as rereading and serial repetition (Brown et al. 2014, Ward and Walker 2008, Roediger and Karpike 2006). According to Ward and Walker (2008), these methods evoke surface processing (reference Table: 1).

Empirical research challenges traditional views on study habits. These research findings support study strategies such as flashcards, self-testing, and creating mental models. These techniques fall under the umbrella of retrieval practice and are classified as deep processing methods. Retrieval practice can be defined by the recollection of information from memory and is said to have a profound impact on student learning (Brown et al. 2014, Karpicke et al 2009, Roediger and Karpicke 2006). Ward and Walker (2008) also support this ideology by suggesting students construct their study routines to involve a more complex approach. In their study, the group of students who practiced techniques that evoked deep processing were more successful than their peers who relied on single-minded methods that induced surface processing i.e., re-reading and massed practice (reference Table 1). Kadri et al. (2011) also reported increased preparedness for assessments and clinical examinations when students in their research study practiced studying with the integration of writing summaries and self-testing. In other studies, where no significant relationship was detected, authors still encouraged professors to educate students on how to modify study routines (West et al. 2014).

II. LITERATURE

Earlier studies have addressed the importance of using deep study strategies as it relates to academic achievement in medical school stating that studying plays an important role in the academic success of medical students, and it is likely that ineffective study skills result in poor academic performance (Tooth 1989). Depending on what study strategies medical students use, they can achieve high scores on exams distributed by the National Board of Medical Examiners such as Comprehensive Basic Science Exams and the United States Medical Licensure Exam Step 1 exam. The effectiveness of study strategies is likely related to successful performances on these exams and merits additional research to test this relationship (Gettinger and Seibert 2002, Kornell and Bjork 2007). Further investigations on study strategies and how they impact student success will aid in increasing academic achievement. In sum, established research on study strategies that benefit students has revealed that these study strategies should pose a challenge, require students to use their own words, involve creating conceptual diagrams, include retrieval efforts, relate to prior knowledge and greater context, and refrain from rote learning techniques such as re-reading and mass repetition.

According to Gettinger and Seibert (2002), students that study effectively are strategists that utilize a series of tactics with goal-oriented intentions. These students can gage their progress and study in a timely manner. In Gettinger and Seibert's (2002) review, the study approach used among two groups of students was investigated. The first group, labeled the academically competent students earned high achievement. The second group included students that struggled with content and had low academic achievement. Students with poor academic performances showed inadequate study skills and a dependency on guidance from an instructor. These students were not proficient in monitoring their learning or tailoring their study approach to optimize learning. They expressed their reliance on passive strategies such as rote memorization. The students in this group reported that they did not focus on the main idea but devoted attention to memorizing material by detail long enough to pass a test. Conversely, the high achieving students reported a tendency to seek out important information, relate main ideas to one another, use prior knowledge, alter their strategies to be most optimal, and finally, gage their understanding when it is not strong to make changes in their study method.

Seibert (2002) also reviewed evidence-based study strategies that support academic success. The four categories of strategies in this study were rehearsal/repetition, organized/procedural-based study strategies, and cognitive- and metacognitive-based strategies. This research study claimed methods like repetition require little processing and generated results that were ineffective. When a good organizational approach is taken, a student has a planned practice. This routine would include varied practice where the student is devoted to completing the tasks that are allotted into manageable increments. A cognitive approach is characterized by a student's ability to focus on the main idea of the content and apply it to what they have learned. Additionally, students who use this approach develop newly organized maps of ideas that consist of both prior knowledge and new information (deep processing technique). The metacognitive study strategists relate to those who are monitoring their strategies for maintenance in their routine. Certain tasks require different techniques. Metacognitive strategists are aware of what study strategies to include and retract in the interest of time and progression. Seibert (2002) concluded that education on how to study is needed in order for students to be more successful in the construction of their routines and therefore in academics because they are greatly unaware (McCabe 2010).

Brown et al. (2014) emphasized the importance of educating students on how to strategically approach studies outside of the classroom. Many people believe that study strategies should be structured around learning styles. Brown et al. (2014) considers this view as a misconception and to defend their stance, used a series of qualitative studies to support counterclaims against widely accepted ideas related to study strategies. They believe that studying is an effortful process where the most effective methods are counterintuitive and that students are not aware of when they are learning if they do not feel productive during the process. Also, students are counter-productive when using techniques such as massed practice, re-reading, and rapid repetition. A study at the University of Mexico supports this idea (Callendar et al. 2009). In this study, 148 students read learning material. A sub-group read the articles once. The other group reread the articles. When given a questionnaire on the readings, there was no long-term advantage in re-reading the material.

Brown et al. (2014) recommend students use retrieval practice where they recall information rather than constant exposure to the material and serial repetition. They also advised students to use varied and spaced practice to challenge themselves along with self-testing techniques. Their claim is that self-regulated study routines should have techniques that rely on memory to retrieve information rather than the popular method of associating mastery with repeating the content precisely.

Among a group of vet students in an anatomy course, there was not one study method that was associated with success and long-term information retrieval (Ward and Walker 2008). Rather than relying on a single study method, the highest ranked students used many study strategies as a collective. Conversely, the students that were struggling usually relied on one study strategy. From this, Ward and Walker (2008) deduced that the key was in the way vet students process information during practice. Phenomenographic analysis divided students into groups according to deep or surface processing. The deep processing group included those that had increased cognitive activity during studying while the others had little cognitive processing. Most of the vet students who adopted multiple study strategies landed in the deep processing category. The results for the deep processing students showed a greater ability to recall information and a higher success in the course overall. On the other hand, students that depended on memorization or a surface processing strategy had poor ability to recall and performed poorly in the class. Like other studies, Ward and Walker (2008) advocated for education on productive study techniques that are predictive of success and information retention.

Hussmann & O'Loughlin (2019) also investigated the importance of study strategies to success in an anatomy course. Four hundred and twenty-six anatomy students completed a survey on their study strategies along with a VARK (visual, aural, read/write, and kinesthetic) assessment tool to analyze their learning styles. The results showed no relationship between study strategies and learning styles. However, some study strategies (use of a microscope) were positively correlated to class performance. Hussmann & O'Loughlin (2019) suggested students and teachers abandon the idea that study routines should align with learning styles to improve class grades. Others share this sentiment and argue that there is no correlation relative to learning styles and academic success, and they claim the advice students receive pertaining to learning styles and academic achievement is completely wrong (Carey 2010). Having a learning style can limit your study routines to a single strategy that may or may not be the most advantageous for the task. Brown et al. (2014) agreed that allegiance to one strategy is counterproductive and makes students less versatile in learning in both the classroom and independently. In his conclusion, Hussmann & O'Loughlin (2019) also proposed an instructional effort on study strategies to eliminate conventional ideas that are restricting students from getting the most out of their study routines.

In a study more related to my project, West et al. (2014) showed that study strategies are related to the performance outcome on the Step 1 licensure exam. Seventy-nine freshman students from the Texas A&M Health Science Center completed a Learning and Study Strategies Instrument (LASSI). This tool is dedicated to assessing study strategies and qualities of independent learning among undergraduate students that major in health. Concentration was the indicator of success on the USMLE Step 1 exam. Like other studies, West et al. (2014) concluded that providing education to students on study strategies and self-management should be implemented in order for them to use strategies that are predictive of success on USMLE.

A reoccurring theme throughout the literature is that we should consider providing education to students on what and how studying is done. There is a discrepancy between how often students are told to study that conflicts with how often they are taught how to study. A trend in the disapproval of single study methods, mainly memorization and repetition based on research evidence has increased. Emerging literature leads us away from some of the traditional counteractive techniques that do not evoke long-term retrieval and academic success. These strategies have been labeled as surface strategies or strategies that do not spark deep cognitive efforts. It is worth considering what other strategies medical students use in their study routines and if these strategies are beneficial. In addition to this, it is important to dedicate research to investigate whether the deep strategies are predictive of academic success and performance on high stakes exams. This study will help contribute to our understanding of what study strategies are most optimal in independent learning efforts. In the end, I hope to be able to provide feedback on what techniques students use that will promote learning and increase testing performances.

III. METHODS

LOCATION:

This study took place in the Midwestern United States at Wright State University Boonshoft School of Medicine located in Dayton, OH, USA. There are about 500 students in attendance at the Wright State School of Medicine.

DATA COLLECTION:

Performance data were collected post matriculation and from standardized exams. In 2017, an electronic survey was distributed via email to 120 first year medical students during orientation at the Wright State University Boonshoft School of Medicine. The survey concentrated on the types of study strategies medical students used, how often they used them, their sentiments towards strategies they used, and whether students studied in groups or in solitude. At a 112-student response rate, the responses from students were given in percent and rated on a Likert type scale. Each student was deidentified and issued a random ID by the director of assessment at WSU Boonshoft School of Medicine. Subsequently, the scores from three standardized exams were recorded. These exams include: the NBME Comprehensive Basic Science Exam 1 and 2, along with the USMLE Step 1 exam.

NBME CBSE & USMLE STEP 1 EXAM

The Comprehensive Basic Science Exam (CBSE) is a standardized test distributed by the National Board of Medical Examiners (NBME). It is four hours long and is composed of approximately two hundred questions. This exam tests students on basic biological concepts. The CBSE is administered to prepare students for USMLE Step 1. A minimum score of 70 on the Comprehensive Basic Science exams is almost equivalent to a 200 on the Step 1 Exam.

The CBSE is given two times during a students' pre-clinical coursework at the Boonshoft School of Medicine: at the end of the first year of pre-clinical work, and again at the culmination of pre-clinical work (February of pre-clinical year 2) prior to dedicated study time for the Step 1 Exam.

According to the United States Medical Examiners (USMLE), the Step 1 exam is reflective of one's ability to apply basic biological concepts to professional practice (McGaghie et al.2011). This exam is approximately 8 hours long and comprised of about 400 multiple choice questions. The minimum score one must achieve to pass the Step 1 Exam is a

194. In addition to this, a passing score on USMLE Step 1 is required both for medical licensure in the United States as well as graduation from Boonshoft School of Medicine.

DEMOGRAPHICS:

The general demographics of the cohort of students from this study included fifty-three males and sixty-two females. Within this cohort, seventy-seven individuals identified as White and non-Hispanic. Eleven individuals identified as African American, non-Hispanic.

Sixteen individuals identified as Asian or Pacific Islander. One individual identified as Hispanic. Three individuals identified themselves under the category of other; and seven students did not answer. Within these groups seven students agreed they were "underrepresented in medicine". Finally, the average GPA of the students in this study was 3.68 on a 4.0 scale. The average science GPA was 3.60 on a 4.0 scale.

QUESTIONAIRE

The Wright State University Boonshoft School of Medicine created a questionnaire to investigate the relationship between study strategies students used and their academic success. The inspiration in collecting data via questionnaires stemmed from the claims made in the book, *Make it Stick* written by Brown et al. (2014). In the book, the authors explained to readers how to become successful learners. Their belief is that popular study strategies are counterproductive to learning. These strategies include highlighting, re-reading, and other rote learning strategies such as repetition. The book shares a compilation of empirical studies that provide evidence counter to common study strategies. Conversely, the collection of studies in *Make it Stick* support study strategies that Brown et al. (2014) believe promote success. According to Brown et al. (2014), the discrepancies in poor learning outcomes and academic success is a result of the lack of cognitive effort involved in the strategies that are popular but counterproductive. This questionnaire investigated the strategies that were popular among students. More specifically, questions in the survey inquired about the amount of time students spent using the following study strategies: re-reading, highlighting, using flash cards, taking and or reviewing notes, cramming, self-quizzing, concept mapping, explaining to self or others and listening to recorded content. An excerpt from the original survey is included below.

QUESTIONAIRE DESIGN:

2021 Orientation Make It Stick Pre-Test

Q1 What is the percent of your time you spend studying in the following manners? (Total must equal 100)

Re-reading text and highlighting: ________ (1)
Flashcards: ________ (2)
Taking notes and reviewing notes: ________ (3)
Cramming: ________ (4)
Self-quizzing: ________ (5)
Producing your own concept maps: ________ (6)
Explaining to yourself or others: ________ (7)
Listening to lectures and recorded notes: ________ (8) Total: ________

Q2 To what extent do you use each of the following study strategies?

	Not at all (1)	A little (2)	A moderate amount (3)	A lot (4)	Extensively (5)
Focused studying on one topic until mastered (1)	○	○	○	○	○
Spaced retrieval practice (studying same content at different times) (2)	○	○	○	○	○
Studying multiple topics per study session (3)	○	○	○	○	○
Variable practice (studying same content different ways) (4)	○	○	○	○	○

Q3 What is the percent of your time spent studying individually or as a group? (Total must equal 100)

Individual studying: ________ (1)
Group studying: ________ (2)
Total: _________

Q4 What is the percent breakdown of your preferred learning styles? (Total must equal 100)

Visual (spatial): You prefer using pictures, images, and spatial understanding: ________ (1)
Aural (auditory-musical): You prefer using sound and music: ________ (2)
Verbal (linguistic): You prefer using words, both in speech and writing: ________ (3)
Physical (kinesthetic): You prefer using your body, hands and sense of touch: ________ (4) Total: _________

Q5 Rate the extent to which you...

	Not at all (1)	A little (2)	A moderate amount (3)	A lot (4)	Extensively (5)
experience stress with final course examinations (1)	o	o	o	o	o
are confident that your study strategies are working (2)	o	o	o	o	o
are comfortable with changing your study habits (3)	o	o	o	o	o
are willing to change your studying strategies (4)	o	o	o	o	o

IV. STATISTICAL METHODS

To evaluate the percent of time students spent using the eight aforementioned study strategies, I conducted a basic summary of statistics based on the data collected from the questionnaire (refer to Q1 of the questionnaire). The focal elements of the descriptive stats as it relates to the percent of time students spent using the eight study strategies are mean, standard deviation, minimum and maximum.

The statistical mean, a commonly used measure of central tendency reveals the average or center point of distribution in the data. The mean is often represented by the symbol $\bar{x}$ ("x bar"). The formula to compute the mean is written below. The Greek letter S (sigma) can be translated as "the sum of". The adjacent letter in the equation, X represents a single numeric value in the data. Together, S X means the sum of all values. The sum of all values should be divided by N, which is the total sample size or the amount of individual numeric values.

For this study, $\bar{x}$ is the average percent of time students spent using a specific study strategy. The sigma is the sum of each percentage of time students reported to use a specific strategy. N is the number of students that reported overall.

$$\overline{X} = \frac{\sum X}{N}$$

STANDARD DEVIATION

The standard deviation (SD) is a statistical measure of variance that gives a representation of how far values are away from the mean. The formula for standard deviation is included below. SD is represented by the Greek letter sigma (s). The formula reads, the square root of the sum of a single value minus the mean squared divided by the total sample size minus one. The division of the quantity of N-1 accounts for the degrees of freedom (df). The first step in calculating the SD is to calculate the mean. The mean is subtracted from each value and squared. The sum of squares is divided by N-1.

$$\sigma = \sqrt{\frac{\Sigma\ (X - \overline{X})^2}{n - 1}}$$

MINIMMUM AND MAXIMUM

The min and max are the highest and lowest points reported in the data. For example, the smallest number (minimum) in the test performance data set would belong to a deidentified student in the study who achieved the lowest score out of all students in the study who took the test. The highest value would belong to a de-identified student in the study who achieved the highest score out of all students that took the test.

CBSE NORMALIZED GAIN

Normalized gain (NG) is a measure introduced by Hake (1998). The formula for normalized gain is displayed below. The NG is an equation that describes the calculated amount of what students learned divided by the quantitative amount of what they could have learned. It's a ratio of the average gain in scores (CBSE2 score – CBSE1 score) over the highest possible gain in average
(95 -CBSE1) (Marx 2007). In the case of the CBSE the max score is not 100 but 95. In many cases the maximum possible gain would be 100 or the value of a perfect score on the specific test.

$$\langle g \rangle = \frac{\langle \text{post} \rangle - \langle \text{pre} \rangle}{100 - \langle \text{pre} \rangle}$$

CBSE CHANGE

I calculated the change in CBSE for each student by subtracting their score on CBSE 1 from their score on the CBSE 2. The change in CBSE is also represented as DCBSE, where the Greek symbol D (delta) means “change in”. The formula can also be represented as follows: (CBSE2- CBSE1).

EXPLORATORY FACTOR ANALYSIS

An exploratory factor analysis (EFA) is a statistical technique that reduces data variables into subsets to explain relationships and variation. The goal of an EFA is to pull out groups of variables that collectively explain the greatest amount of variance. An EFA extracts items from within an analysis of covariance matrix identify groups called factors. The factors that are extracted explain the covariance in data. The data that show predictable patterns, commonalities, or cluster indicate relationships (Hooper 2012, Henson and Roberts 2006, Costello 2005).

In this study, I sought to investigate the relationship between learning strategies and performances on exams. The questionnaire was an instrument created to collect information to measure the influence of learning performances on the CBSE1, CBSE2, and the Step 1 exams. I ran an exploratory factor analysis on the 8 study strategies and exams. The maximum likelihood estimation and promax rotation were utilized in this analysis. The eigenvalues retained were values greater than 1 (Hooper 2012, Henson and Roberts 2006, Costello 2005, Kaiser 1960). A total of 4 factors were deduced from the 8 learning strategies as observed variables. The software commands were set to save factors as "regression scores" in order for the output to report normalized scores centered at 0 with a SD of 1. The Eigenvalue refers to the number of variables in the set that the factor explains. For example, an Eigenvalue of 1 would mean that 1 factor explains 1 of the 8 variables and therefore, 12.5% of the total variance. Values that are less than one is usually omitted (Henson and Roberts 2006). The variables and responses from the questionnaire produced a large amount of data to analyze. The exploratory factor analysis aided in organizing and reducing the data.

CATEGORIZING STRATEGIES INTO DEEP VERSUS SURFACE PROCESSING

Following Brown et al. (2010), each of the eight study strategies in this study were placed in one of two categories, surface, or deep processing techniques. Brown et al. (2010) categorized the strategies into deep or surface by the level of cognitive engagement they produce. If the strategy solicited increased cognitive activity and processing, it was considered deep. Conversely, if it required limited cognitive processing or engagement, it was considered surface level. Deep strategies examined in this study were flashcards, concept mapping, self-quizzing, and explaining to self or others. Strategies that pose difficulty and require learners to recall or draw information from memory are deep processing strategies. The umbrella term used to define the task of retrieving facts from memory is called retrieval practice.

The remaining four strategies examined in this study are highlighting, reviewing material, cramming, and replaying material. These strategies are categorized as surface processing strategies and fall under the umbrella of massed practice. Massed practice techniques are defined by the single-minded effort of repetition to sync information into memory. Massed practice techniques are all surface techniques and have little to no benefit in anchoring information into memory and are ineffective for learning.

V. RESULTS

I ran a descriptive analysis on the percent time students spent using the following study strategies: re-reading, highlighting, flashcards, taking and reviewing notes, cramming, self-quizzing, concept mapping, explaining to self and or others, and listening to lecture and or recorded notes (Table 1). Students prefered reviewing notes (a surface processing strategy) over all other strategies and used this strategy about 27% of the time on average. The second most popular study strategy and the most popular deep study strategy was self-quizzing. Students spent an average of 14% of their time self-quizzing. On average, students spent about 12% of their time explaining to self or others and using flashcards (deep processing strategies). Students spent about 11% of their time on average highlighting and creating concept maps. Finally, the least popular strategies were cramming (9%) and replaying lecture and/or notes (5%).

The distribution of scores for CBSE 1, CBSE 2, and Step 1 exam, as well as the distribution of the change in CBSE (CBSE gain or CBSE), are listed in Table 2. The mean score for the Step 1 was 228.70 with a standard deviation of 16.54. Students' Step 1 scores ranged from a minimum of 184 to a maximum of 269 (maximum possible value = 300). CBSE1 had a mean score of 48.41 and a standard deviation of 6.22. The CBSE1 scores ranged from a minimum of 33 to a maximum of 68 (maximum possible value = 100). The mean score on CBSE 2 was 71.11 with a standard deviation of 9.73. CBSE2 scores ranged from a minimum of 52 to a maximum of 96 (maximum possible value = 100). The change in CBSE had a mean of 22.69 with a standard deviation of 7.97 and ranged from a minimum of 7 to a maximum of 42. Finally, CBSE normalized gain had a mean of 0.45 and standard deviation of 0.13. Students' normalized gain ranged from a minimum of 0.13 to a maximum of 0.90.

I ran a univariate linear regression to examine the relationship between the percent time spent using deep study strategies as the independent variable (flashcards, concept maps, self-quizzing, and explaining to self and or others) and Step 1 scores, CBSE1 scores, and CBSE2 scores as dependent variables (Table 3). There was no significant relationship between deep learning strategies and the Step 1 exam score ($P > 0.05$) or CBSE ($P > 0.05$). With a P value of 0.09, there was a slight trend but, no significant relationship between deep learning strategies and CBSE normalized gain (P value >0.05).

I also ran a univariate linear regression to examine the relationship between the percent time spent using deep learning strategies (independent variable) on CBSE (dependent variable; Table 4) and normalized gain (Table 5). There was no significant relationship between the percent of time spent using deep learning strategies and either measure of change ($P > 0.05$).

The exploratory factor analysis examining the combinations of learning strategies that students tended to use together identified four factors that had eigenvalues greater than 1, which together explained 69% of the cumulative variance (Table 6). These four factors were retained for further analysis. The structure matrix indicated that three strategies (Self-quiz, Concept Mapping & Explaining) had high positive loadings and one strategy (Reviewing) had a strong negative loading on factor 1 (Table 7). Thus, factor 1 suggests that students who used deep-learning strategies tended to use a combination of strategies at the expense of reviewing. This factor was renamed as contextualization (Table 7.1). The contextualized strategies in factor 1 were named after their common aim to cognitively engage students, link the material to prior knowledge and experiences that are relevant, and build broader connections to solicit a deep, lasting understanding.

The remaining three factors were renamed as (1) Flashcards, (2) Reviewing, and (3) Replaying, based on the study tactics that had high positive loadings. Flashcards and reviewing had positive correlations with contextualization (Table 8). Contextualization had a positive correlation whereas reviewing had a positive correlation with flash cards. Both contextualization and flashcards have a negative correlation with reviewing. Finally, contextualization and flashcards had a positive correlation with replaying.

Contextualization was the only factor with a positive coefficient, indicating a positive relationship with performance on the Step1 exam (Table 9). This relationship was also the only significant relationship between factors and Step 1 scores ($p < 0.05$). All other factors hada negative coefficients, suggesting negative relationships with Step 1 scores, but these relationships were not statistically significant ($p > 0.05$).

There was also a non-significant trend for contextualization to be positively related to CBSE gain (Table 10), but the relationship was not quite significant at the 95% confidence level ($P = 0.085$). All other factors had negative coefficients, suggesting a negative relationship (decreased CBSE gain).

VI. TABLES

Table 1. Descriptive statistics summarizing the percent of time students spent using each study strategy, and the categorization of each study strategy into deep (D) or surface (S) learning.

Descriptive Statistics of Percent Time Spent Using Deep & Surface Learning Strategies						
Strategy	**N**	**% Mean**	**% SD**	**Min**	**Max**	**Deep or Surface?**
Highlight	111	10.88	14.97	0	90	S
Flashcards	111	11.63	14.15	0	70	D
Reviewing	111	27.1	18.47	0	90	S
C. Map	111	10.59	11.94	0	50	D
Cramming	111	8.59	9.63	0	40	S
Self-quiz	111	14.28	14.29	0	65	D
Explaining	111	11.71	9.15	0	50	D
Replaying	111	5.30	7.26	0	30	S

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Table 2. Mean, standard deviations (SD), and range (minimum, min, and maximum, max) of scores for the CBSE 1 and 2 and STEP 1 exams, and the average improvement on scores between CBSE 1 and 2 (change in CBSE scores, CBSE, and normalized gain, Normgain).

Test	N	Mean	SD	Min	Max	Max Points
STEP 1	111	228.70	16.54	184	269	300
CBSE 1	111	48.41	6.22	33	68	100
CBSE 2	111	71.11	9.73	52	96	100
CBSE	111	22.69	7.97	7	42	100
Normgain	111	0.45	0.17	0.13	0.90	100

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Table 3. Results from the linear regression examining the relationship between deep processing strategies and the Step 1 exam scores.

	SS	df	MS	F	p-value	r-square
Regression	447.9	1	447.92	1.6456	0.2022	0.005843
Error	29653.3	109	272.05			
Total	30101.2	110	710.05			

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Table 4. Results from the univariate regression examining the effect of percent of time spent on deep learning strategies on CBSE.

	SS	df	MS	F	p-value	r-square
Regression	62.2	1	61.18	0.9788	0.3247	-0.00019
Error	6925.4	109	63.536			
Total	6987.6	110	124.716			

Table 5. Results from the linear regression examining the relationship between deep processing strategies and the CBSE normalized gain.

	SS	df	MS	F	p-value	r-square
Regression	0.07484	1	0.0748	2.7625	0.09	0.09937
Error	2.95289	109	0.0271			
Total	3.02773	110	0.1019			

Table 6. Summary of the eigenvalues and the variance explained by each of the factors from Exploratory Factor Analysis exploring learning strategies that students tend to use together.

Factor	Eigenvalue	% of variance	Cumulative % of variance
1	1.832	22.956	22.956
2	1.348	16.848	39.804
3	1.315	16.434	56.238
4	1.004	12.554	68.792
5	0.926	11.573	80.365
6	0.832	10.397	90.726
7	0.738	9.229	99.991
8	.001	.009	100.000

Table 7. Loadings of each study strategy (categorized as deep- or surface-learning) on each of the four factors retained from the Exploratory Factor Analysis.

Group	**Strategy**	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**
		Contextualization	Flashcards	Reviewing	Replaying
Deep	Flashcards	-.002	.931	-.019	.088
	C. Mapping	.498	-.102	-.023	-.065
	Self-quiz	.518	.073	.069	.255
	Explaining	.394	-.021	.034	.014
Surface	Highlighting	-.051	.005	-.918	-.122
	Reviewing	-.845	-.649	.646	-.404
	Cramming	-.028	-.156	.074	-.154
	Replaying	.144	.112	.062	.980

Table 7.1. Descriptive terms, based on loadings of the study strategies used for each of the retained factors from Exploratory Factor Analysis.

Factor	Name	Description
1	Contextualization	Self-quiz, Concept Mapping & Explaining
2	Flashcards	Driven by use of flashcards
3	Reviewing	Driven by reviewing lecture/notes
4	Replaying	Driven by replaying lecture/notes

Table 8. Correlations between the factors. Asterisks indicate correlations that are statistically significant (*P* < 0.05).

Factor	Name	1	2	3	4
		Contextualization	Flashcards	Reviewing	Replaying
1	Contextualization	1.00	0.31*	0.26**	0.06**
2	Flashcards	0.31*	1.00	0.29**	0.01**
3	Reviewing	0.26*	0.29*	1.00	0.00
4	Replaying	0.06	0.01	0.00	1.00
n=111	* = 0.05				

Table 9. Regression coefficients for the effect of each of the factors from Exploratory Factor Analysis on STEP 1 score.

	Factor	B	SE	T-score	p-value	partial r-square
1	Contextualization	5.530	1.720	3.215	.002*	.298
2	Flashcards	-2.139	1.666	-1.284	.202	-.124
3	Reviewing	-.029	1.640	-.018	.968	-.002
4	Replaying	-1.505	1.628	-.924	.358	-.089

Table 10. Regression coefficients for the effect of each of the factors from Exploratory Factor Analysis on CBSE.

	Factor	B	SE	T-score	p-value	partial r-square
1	Contextualization	1.474	.847	1.740	.085	.167
2	Flashcards	-.359	.821	-.438	.662	-.042
3	Reviewing	-.832	.808	-1.030	.305	-.100
4	Replaying	-1.081	.802	-1.348	.181	-.130

VII. DISCUSSION

In this study, I identified popular study strategies among the WSU medical students and examined the relationship between the learning strategies students used and their success on academic performance measured by scores students achieved on USMLE Step 1 exam and NBME Comprehensive Basic Science Exams 1 and 2.

The findings in this study reveal that medical students at Wright State University Boonshoft School of Medicine have a strong preference for reviewing notes above all other study strategies (average of 27% of time; Table 1). Students' tendency to use this surface strategy the most could stem from their false sense of mastery due to repeated exposure to the text. Also, students lack awareness in the discrepancies of their study routines and academic performance (Brown et al. 2014). The deep learning strategy students tend to use the most is Self-quizzing (average of 14%). The least popular deep study strategy among students is concept mapping (11% of time on average) while the least popular surface strategy is replaying lecture and/or notes (5% of time on average).

I found no relationship between the deep learning strategies medical students used and their performances on the USMLE Step 1 exam ($p > 0.05$). There was also no significant relationship between deep learning strategies students used and student's gain in CBSE or CBSE normalized gain ($p > 0.05$).

Results of the exploratory factor analysis explained 69% of variance in the data across 4 factors (reference Table 6). Contextualization (Factor 1) was driven by concept mapping (0.498), self-quizzing (0.518), and explaining material (0.349). However, students who leaned more towards contextualization did not engage in reviewing notes (-0.845). Students that used flashcards (Factor 2 at 0.931) did not tend to review material (-0.649). This could stem from students successfully anchoring information into memory based on the reliance on optimal, deep strategies (contextualization and flash cards) rather than surface strategies (reviewing notes and reviewing material). Students that relied on reviewing (0.646) did not engage in highlighting (-0.918). Finally, students that leaned towards replaying (Factor 4 at 0.980) did not engage in reviewing (-0.404). This can be explained by students having an allegiance to a single surface strategy that is often ineffective, providing a false sense of learning and mastery (Brown et al. 2014 and Hussmann, O'Loughlin 2019, Ward and Walker 2008).

Of the four factors, the first two are considered deep while the last two can be categorized as surface. The split in factors that describe variance can stem from student’s lack of education in productive learning strategies and their inability to gage when they are learning (Brown et al. 2014). Students that showed a preference in strategies that did not involve them facing challenges are likely to rely on surface strategies because they are intuitive and therefore produce false impressions of mastery

to the students (Brown et al. 2014).

According to the regression, students that spent more time using contextualization practices defined by the use of concept mapping, self-quizzing, and explaining, performed better on the Step 1 exam ($p < 0.05$). Deep learning practices like contextualization require cognitive effort and do not focus on memorization techniques that evoke little cognitive work and retrieval practice (Brown et al. 2010, Seibert 2002). In addition to this, not depending on a single method, but a varied approach is linked to anchoring knowledge as well (Brown et al. 2014, Ward and Walker 2008). Therefore, it was predictable to see no relationship between the surface processing practices and increased Step 1 scores. In addition to this, contextualization showed a positive trend in the CBSE gain. This relationship was not as strong as the correlation between use of contextualization and Step 1 scores.

It’s understood that effortful study routines involving the use of productive study strategies are important for academic success in medical school. This study addressed the need in identifying what specific independent learning strategies increase academic success for medical students at WSU Boonshoft School of Medicine.

Unfortunately, the learning strategies medical students showed a preference in are defective in anchoring knowledge and do not solicit increased performance results on their high stakes exams such as the Step One Exam and CBSE 1 and 2. Students preferred relying on rote learning strategies that emphasize memorization such as re-reading, replaying, reviewing, and highlighting learning content. This stems from the misconception that mastery occurs after repeated exposure to material (Brown et al. 2014, Karpicke, 2009, Ward & Walker, 2008). Counterproductive study strategies result in a pseudounderstanding of material and hinder metacognition (Brown, et al. 2014, Ward & Walker, 2008). Such surface-level strategies have not only shown limited productivity on standardized exams, but licensure exams as well (Mendezabal, 2013). Empirical studies suggest students use deep processing study strategies defined by their demand in cognitive effort. Examples of these strategies are the use of flash cards, self-quizzing, creating concept maps, and explaining content to self and or others (Brown et al., 2014, Callendar & McDaniel, 2009, Gettinger & Siebert 2002). Researchers argue that effective learning happens when students use deep processing strategies that pose challenges rather than depending on single-minded learning strategies that evoke limited cognitive
engagement like massed practice (Brown, et al. 2014, Ward & Walker, 2008).

Relying on study methods that are not beneficial is widely relatable. This study is important in informing students at Boonshoft School of Medicine to consider unlearning many things they thought they knew about learning and proper study methods, specifically dismantling the idea of studying based on repetition and learning styles. Learners should not be afraid to learn things the hard way. Desirable difficulties in learning are the challenges we need to become strong learners (Carey 2010, Roediger and Karpicke 2006).

Students should consider studying with intentions to master the material using retrieval methods like testing themselves rather than allowing an approaching test or an exam be their sole motivation to rapidly burn information into memory and inducing testing anxiety (Roediger et al. 2016, Brown et al 2014, Roediger et al. 2010. Roediger and Karpicke 2009). During self-regulated learning, students should take initiative by challenging themselves with low stakes quizzes, concept mapping, and explaining to others (contextualization) as a measure to learn and prepare for major exams. Even if a method doesn't feel productive, it is likely a student is progressing (McDaniel et al. 2011, Brown et al 2014) as long as the student is taking the proper learning approach.

It's important to mention that because the independent variables in this study are percent of time spent, they are inversely correlated. In other words, if one spends more time using deep study methods, this automatically means the amount of time students use surface study practices will decrease. Also, the amount of time students spent using study strategies was not identified in the survey. Asking the percent of time spent using a study strategy and not the amount of time studying overall was a disadvantage because students overall study routines could last just a few minutes and would not be as informative on performance scores. Along with this, it is possible that better performances on subsequent tests are impacted by exposure to classroom material throughout the year as well as study strategies students used.

My study and many of the studies mentioned above concluded in the need for more research dedicated to informing students about optimal study strategies that increase learning and academic success. Even after finding that the use of deep strategies like contextualization promote increased learning and academic achievement- specifically on the USMLE Step 1 exam, there is still a knowledge gap that leaves room to discover more about how we learn. For example, future studies can address newly formed questions such as: ‘Why do deep processing strategies benefit students more; perhaps they are more fun because facing challenges is motivating and subconsciously entertaining?’ To what level does motivation and setting goals impact study strategies and learning? In addition to this, questions about the relationship between academic performance and students' tendency to study individually or in a group arise as well. Finally, ‘does the amount of time spent studying while using contextualization (practices defined using concept mapping, self-quizzing, and explaining) strategies have a strong relationship with academic performance as well?' Future studies can address these questions and many more to improve our understanding of learning and academic success of students.

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