Reduction of Student's Exam Grade Performance When Spending More Time in an Exam

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Author's contribution

This whole work was carried out by author NDT.

Original Research Article

ABSTRACT

Aims: This study aims to establish the correlation between the duration to finish an exam and the student's exam performance quantitatively. The goal is to determine statistically whether spending more time in an exam can improve the exam grade performance.
Study Design: An advanced senior level undergraduate neuropsychopharmacology course and an introductory freshman level biology course were selected in this study to compare the student's exam performance with respect to the sequential time order of the exam completion. Both courses had similar number of questions (50 multiple-choice questions) in the exams and similar enrollment size (>100 students), so comparison of the exam performance can be made.
Place of Study: Department of Biological Sciences, University of North Texas.
Methodology: Sample: 8762 student-exam samples were collected from 93 closed-book exams (50 exams from the biology course and 43 exams from the neuropsychopharmacology course). Population: University students enrolled in the above courses. Enrollment size: 90±24 (mean±standard deviation) students for the biology course and 99±11 students for the neuropsychopharmacology course.
Statistical Analysis: Cusum (cumulative sum) slope trend analysis statistics were used to quantify the statistical sequential trend of grade performance in relation to the exam completion duration.
Results: The results show there is negative correlation between the time a student spent in an exam and the exam grade. There is a 5% decrease in grade performance for those

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students who completed the exam last, compared to those who finished the exam first. This decreasing trend of grade performance exist for both courses, even though the students in the senior level course performed better by 6% in the class average than the freshman course. The consistent trend is that the above-average performing students are the first to finish the exam, while the below-average performing students tend to finish last. The 5% reduction in grade performance corresponds to half of a letter-grade in the A-F American grading system — i.e., a 0.5 grade point reduction in the GPA (grade point average).

Conclusion: The statistical analysis shows that the longer time a student took to complete an exam, the worse the grade performance. This is contrary to the common notion that taking more time to complete an exam may lead to a better grade or may lead to an unfair advantage over other students. This provides insight to educators and students to decide whether providing extra time for students to complete an exam is linked to a better grade performance or a poorer performance, when more time is spent to complete an exam.

1. INTRODUCTION

An exam is typically a part of the assessment process to provide feedback to both students and instructors to determine whether the students have acquired the knowledge in a course. Yet, there are no quantitative analyses on what is the appropriate amount of time provided to the students to finish an exam and whether the time a student spends in an exam would affect the grade performance outcome. That is, if the assumption that the amount of time available in an exam can affect the student's performance, then does providing more time for students to finish an exam than is appropriate will lead to a better grade performance or a worse grade performance?

1.1 Research Questions

For educators, the question is: Does providing students with extra time to finish an exam lead to an unfair advantage that results in a better grade?

For students, the question is: Does taking more time to finish an exam would help getting a better grade because of the extra time?

1.2 Aims

In this study, the aim is to determine statistically whether the time duration spent in an exam can affect the grade performance. That is, we want to find out if the time spent in an exam is a factor that affects the student's performance. If it is a factor that correlates with the student's performance, then does spending more time in an exam improve the grade performance or does it reduce the performance?

1.3 Hypothesis

The common notion is often assumed that if extra time were available for an exam, then the student's grade performance would improve. But this hypothesis has not been tested

quantitatively to verify if the above assumption is indeed true. If this assumption is proven not to be true statistically with quantitative measures, then it may dispel the myth that if a student requests extra time in an exam, it does not necessarily lead to an unfair advantage in grade performance. Furthermore, if students were second-guessing the answers by spending more time in an exam, it could actually decrease the grade performance. Then it may be wise not to spend the extra time in an exam, if the statistics show that poor performance is linked to spending too much time in an exam.

1.4 Rationale

In teaching a course, there is usually a vast amount of knowledge that the instructor expects the students to acquire in the process. In order to assess whether the students acquired the expected knowledge, the instructor usually quantifies the student's performance statistically by sampling the student's knowledge with a representative sample of questions related to the course materials. Most exams are conducted using a random sampling methodology to provide such representative sample as a measure of a student's performance. Yet, there are many factors that can affect a student's exam performance, which may or may not be a direct measure of the proficiency of knowledge that is being assessed.

Thus, it is essential to identify the factors that can affect the outcome of exam performance, so that both learners and educators can address them more effectively. In other words, does test-taking ability affect the student's grade performance? If so, what are the environmental factors that affect a student's test-taking ability and is the time spent in an exam one of these factors?

1.5 Literature Review

The factors that can affect student's exam performance can be subdivided into two categories – internal/intrinsic personal factors and external/extrinsic environmental factors. The intrinsic personal factors are the psychosocial factors associated with the learner (such as confidence, self-efficacy and anxiety, etc.) that can affect student's exam performance [1-5]. The extrinsic factors are the settings in which the course is administered (such as class size, on-line vs. in-class, attendance and the pedagogical method, etc.), which can also affect student's exam performance [6-10]. Interestingly, the use of problem-based learning (PBL) pedagogical method has selective advantage only on the kinds of exam questions that are related to the concept of elaborated vs. dispersed knowledge compared to lecture-based teaching pedagogy [11].

Class attendance can impact student's performance by 9 to 18% improvement in exam performance in a randomized study [6]. Cumulative attendance of lectures corresponds to a 4% improvement in exam performance [7]. Skipping class also affect exam performance — a 10% increase in a student's overall attendance rate results in an increase in the final exam score by 0.17 standard deviation [12]. School size can also affect student's performance with a nonlinear relationship (in the form of an inverted-U) between school sizes [8].

Among the intrinsic factors, self-efficacy serves as a motivational factor for positive cognitive engagement and exam performance [1,2]. The belief of high self-efficacy predicts success, while low self-efficacy appraisals and weak malleability belief predicts failure [1]. Self-efficacy, self-regulated learning and test anxiety are reported as the best predictors of exam performance [2].

Goal-setting (self-regulatory thinking) can affect exam performance, which depends on the specific self-ascribed academic goals as the most important [13]. Students who set *mastery* as the most important academic goals had the highest positive arousal but low exam performance, whereas students who set *performance* as the most important academic goals had the highest negative arousal but high exam performance, which becomes the self-fulfilling prophecy in exam performance. Achievement goal for mastery of subjects with persistence and effort (performance-approach) is also a positive predictor, while disorganization (performance-avoidance) is a negative predictor of exam performance [14].

The expectation to do well on their exams positively affects exam performance [15]. Internal factors (such as student's ability and effort) are associated with success, while external factors are often associated with low performance to avoid blame for failure by being ego-defensive [15,16]. But fear of success or fear of failure does not affect exam performance [17].

Study strategy also affects exam performance [18]. Students engaging in deep study approach (method) to study improves exam performance of complex exam questions more than surface study approach only, but not less complex exam questions [19]. Acquiring specific skill, such as math skill, contributes more to exam performance than test anxiety or skill deficits [3].

There is also an interrelationship between internal and external factors, which can affect exam performance. In a study that compares the gender difference in exam performance in medical students [4], female medical students significantly score higher in emotional intelligence (EI) scale on physician empathy and communication skills than male counterparts. A direct (statistical significant) effect of gender and EI on exam performance existed in autumn semester only, but no direct effects existed in spring or summer semester performance [4].

1.6 Purpose of the Study

Given that there are so many intrinsic and extrinsic factors that can affect exam performance, this study investigates another factor that had not been examined before — the time it takes to finish an exam. The study is designed to address the question whether exam performance is related to the amount of time a student spends on finishing an exam. This is an important question for both students and teachers to identify what is the appropriate amount of time allotted in the exam period and to find out whether spending more time in an exam will result in a better grade performance.

2. METHODS

2.1 Sampling Procedures

Two courses were included in this study — an undergraduate-level freshmen biology course and a senior level neuropsychopharmacology course. The exams from these two courses were closed-book exams. The time-orders of the exams in which the students handed in the exam were recorded during the exam period. The grades of the exams were recorded after the exams were turned in. The sampled student population is the university students enrolled in the above courses.

The freshman biology course is a *required* prerequisite course for all biology majors, whereas the senior neuropsychopharmacology course is an advanced level *elective* (optional) course, which requires the above freshman biology as prerequisite before students can enroll in it. These two courses were used to compare whether there is any difference in grade performance depending on the level of the course or whether the course is required in the student's curriculum. To ensure fair comparison between these two courses, both sampled courses were taught by the same professor. Both courses are large size classes (>100 students) to ensure there is sufficient statistical power for the analysis.

All exams were provided with sufficient time (50 minutes) for students to finish the exams, so the students were not under time pressure to finish the exams. It is essential to allow enough time for students to finish the exam, so that this study can exam the effects of whether spending more time than necessary by the students could affect the outcome of their grades.

All exams are multiple-choice questions (50 questions per exam) without any essay or written questions, since essay writing exam can affect exam performance, particularly for those students with low level of writing skill in handwriting fluency [20]. All exams reported here are face-to-face courses with exams administered in class. Online exams (or online courses) are not included in this study due to the difference in pedagogy and physical environment, which has shown to affect exam performance for in-class vs. online courses [9]. Thus, comparison between similar exam environments with the same number of questions (50 questions per exam) and the same amount of time allotted for each exam (50 minutes per exam) for these two courses can be made.

2.2 Statistical Analyses

The sequential orders of exam turned in by students during the exam period were recorded and analyzed with the corresponding grades scored for that exam. The sequential order is used as a measure in this study (instead of the actual time-duration) because the relative time that each student took relative to his/her peers in the same exam is a more relevant measure than the actual clock-time spent in that exam, due to the difference in the difficulty of each exam for each course.

In order to determine the timing relationship between the grade performance of the students who turned in the exam early and those who turned in late, we use the cumulative sum (cusum) trend analysis statistically [21]. Due to the variability of the sequential order of exams returned, the cusum trend statistics is performed to reveal the underlying trend. The cusum-slope method is a superior trend analysis method than the cusum method, which filters out the local variability (fluctuation) of data to reveal the underlying sequential trend with statistical fluctuations removed [22,23]. It is a quantitative measure to establish serial correlation in a time-series of data that can provide evidence of both local and global trends. The cusum-slope method is a special moving-average method that uses different sliding windows (which serve as band-pass filters) for noise removal.

3. RESULTS

A total of 93 closed-book exams were analyzed — 50 exams from the freshmen biology course and 43 exams from the senior level neuropsychopharmacology. The average size of the classes is 90±24 (mean±standard deviation) students for the biology course and 99±11

students for neuropsychopharmacology. A total of 8762 student-exam samples were collected for these two courses.

3.1 Comparison of Student Performance for All Courses

Fig. 1 shows the exam average grades of the sequential order of the exams returned by students for all 93 exams in the biology and neuropsychopharmacology courses. It shows a general trend of better grade performance for those students who returned the exam early than those who returned the exam late. Fig.1A shows the average exam grades of returned exam from the beginning to end of exam period. There is a decreasing trend in grade performance — the more time students took to finish the exam, the worse the grade performance.

The variability of the sequential order of the time-series is shown in Fig. 1B fitted with the cusum-slope trend analysis statistical moving average. Fig. 1C–E reveals the underlying trend much clearer with different sliding-windows of the moving averages for the cusum-slope analysis to achieve different smoothing effects, analogous to using a different band-pass filter for noise removal. It can be seen that there is a 5% point reduction in grade performance for those students who return the exam first, compared to those who returned it last. Note that the 5% point is equivalent to one half of a letter-grade for a 10%-point letter-grading system (A, B, C, D and F grades) in the American grading system. This shows that students who finished the exam early performed significantly better than those who finished late, contrary to the common notion that spending more time on an exam will perform better.

3.2 Comparison of Student Performance for Freshman Biology and Senior Neuropsychopharmacology Courses

In order to delineate whether such trend is specific to any particular course in terms of their difficulty and depth of materials covered in the course, the freshman biology course is compared with the senior neuropsychopharmacology course. The general biology course is an introductory freshman-level survey course that covers the breadth of materials in the biological systems ranging from animals and plants to ecological systems. On the contrary, the neuropsychopharmacology course is an advanced level course that covers in-depth materials in neuroscience, psychology and pharmacology. It integrates comprehensive knowledge of the neurobiological basis of psychiatric medicine in treating mental disorders. It is a highly demanding course with high expectation for students to comprehend the neurobiological basis of mental disorders and how the pharmacological therapies work to treat these disorders, which requires integration of knowledge and applies such knowledge in clinical case studies. This comparison will allow us to examine whether the depth and breadth of materials in the course can affect the exam performance.
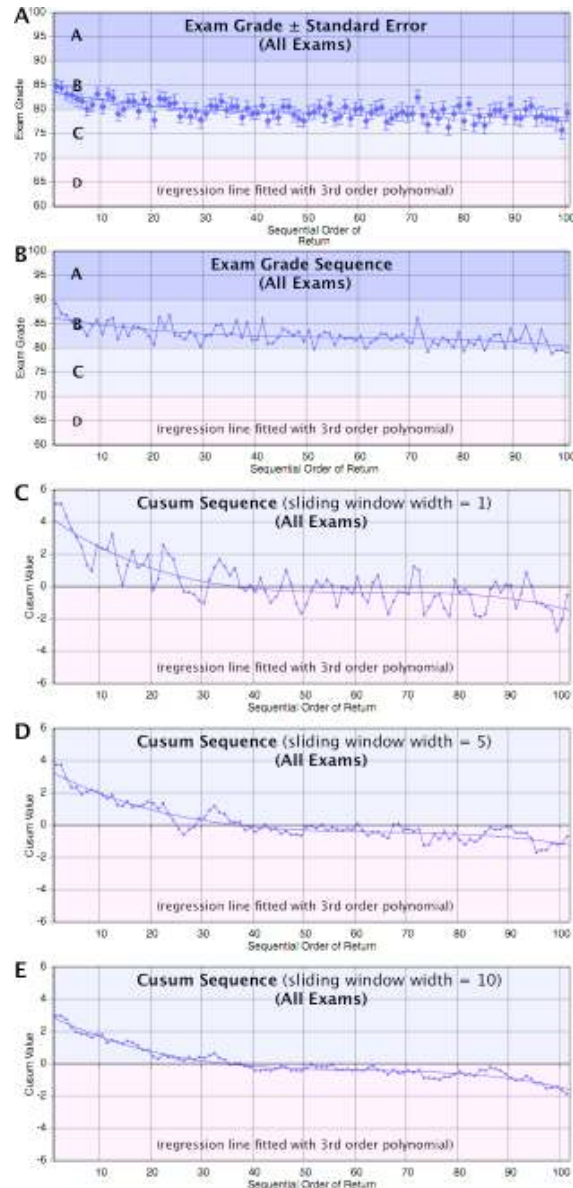
Fig. 1. The sequential order of exam grade average returned by students for all exams in both biology and neuropsychopharmacology courses. The data included both freshman biology and senior neuropsychopharmacology courses. (A) Exam grade average with error bars representing standard error of means. The letter grades (A, B, C, and D) are shown on the graph that represent 90%, 80%, 70% and 60% exam score. (B) Exam grade average sequence represents the trend more visibly (without the standard error bars). (C) Cusum-slope analysis of exam grade represents the sequential trends using sliding-window = 1. Pink shaded area in the graph represents below average performance, while light blue shaded area represents above average performance. (D) Cusum-slope analysis using sliding-window = 5. (E) Cusum-slope analysis using sliding window = 10. (Regression line is fitted with a 3rd order polynomial for all graphs, except Fig. 4.)

Fig. 2 shows the sequential trend of exam grade performance for the neuropsychopharmacology course, while Fig. 3 shows the trend for the biology course. The graphs show similar trend of better performance for those students who returned the exam first than those who returned it last. Both courses show similar trend (see Figs. 2 and 3) that those students who turned in the exam early tend to perform better than those who turned the exam in late. The only difference is the grade average, with a class average of 77% correctly scored for freshman biology course (see Fig. 3) and 83% scored for senior neuropsychopharmacology course (see Fig. 2). This shows that students in an in-depth advanced level course scored 6% better on average than an introductory level course.

Note that, in most of these exams, students had ample amount of time to finish the exam within the allotted exam period that they rarely stayed for the entire 50-min exam period. Students were not under time pressure constraints, which could affect the exam performance, if students ran out of time to finish the exam. Thus, the results shown here are representative of the student's performance without any time pressure.

3.3 Case Study: Comparison of Student Performance in a Typical Exam

In order to provide better insights on the variability of sequential trend during an individual exam rather than based on summative averaged data, Fig. 4 shows the sequential order of grade performance for a single exam in the biology course (rather than the averaged results as shown in Figs. 1-3. Although there is a global trend that better-performing students finished the exam early, there are also a large number of students who performed equally well took time to finish the exam, during the latter part of the exam period.

In fact, there is evidence that local trends exist in the sequential order, as revealed by the fluctuation of trends see Fig. 4D that show students with similar performance often finished the exam at about the same time. That is, the sequential order of students who left the exam is not independent of other students, but serially dependent on each other.

The oscillatory pattern in Fig. 4D indicates that there were clusters of both better-performing and poorly-performing students who often returned the exam at about the same time. The above phenomenon may represent the social coercion effect [24]. When one of their friends finished the exam, the other often followed suit and finished it instead of staying longer than necessary. This bandwagon effect could have an effect on student's performance, even though such effect may not be causally related, except that there is a correlation between the grade performance of those who turned in the exam at similar time.

Finally, as an antidotal observation, there are F grade (failing) students who returned the exam at the beginning of the exam, even though there are more F students turning in the exam during the latter half of the exam period than the first half (see exam grades in the pink shaded area in Fig. 4A). (Note that 10th order polynomial regression line fit is used in Fig. 4D to better reveal the local oscillating trends for an individual exam compared to the 3rd polynomial regression line fit for other graphs.)
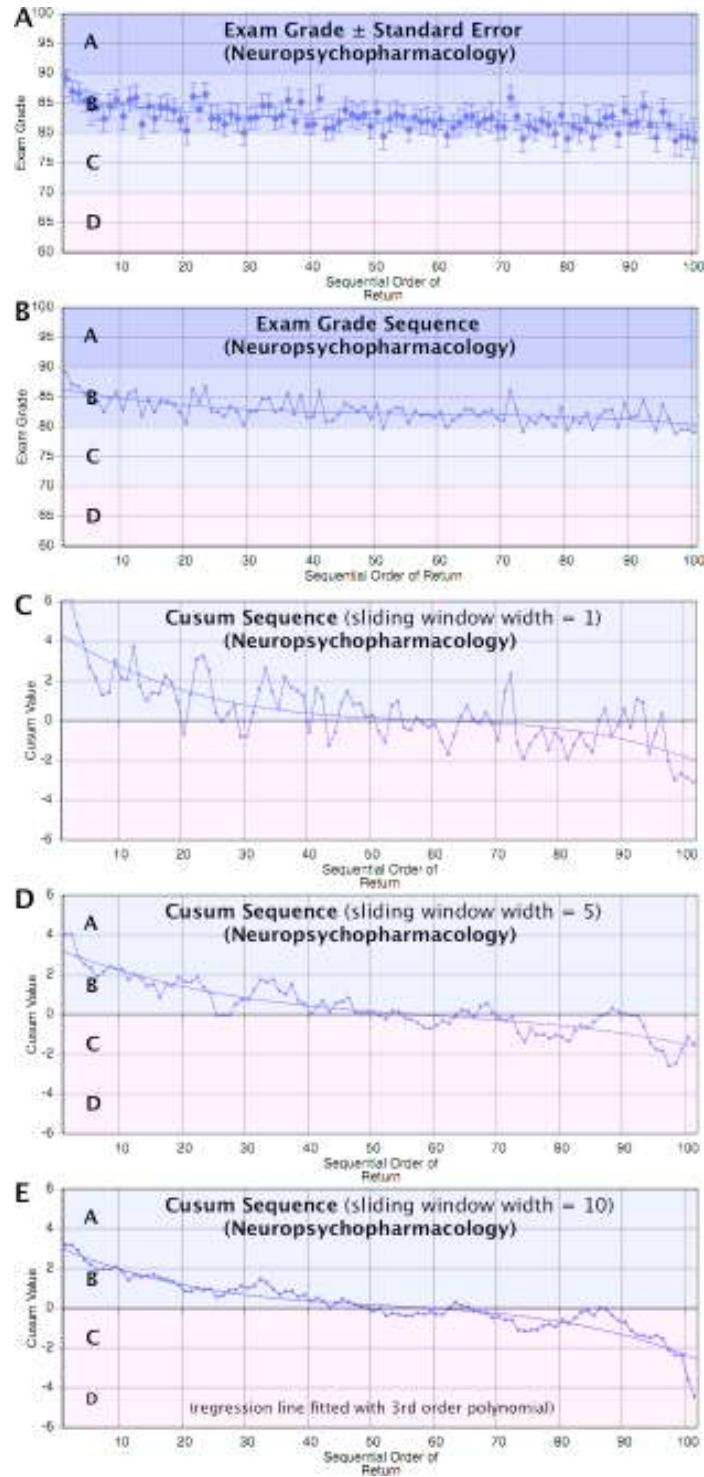
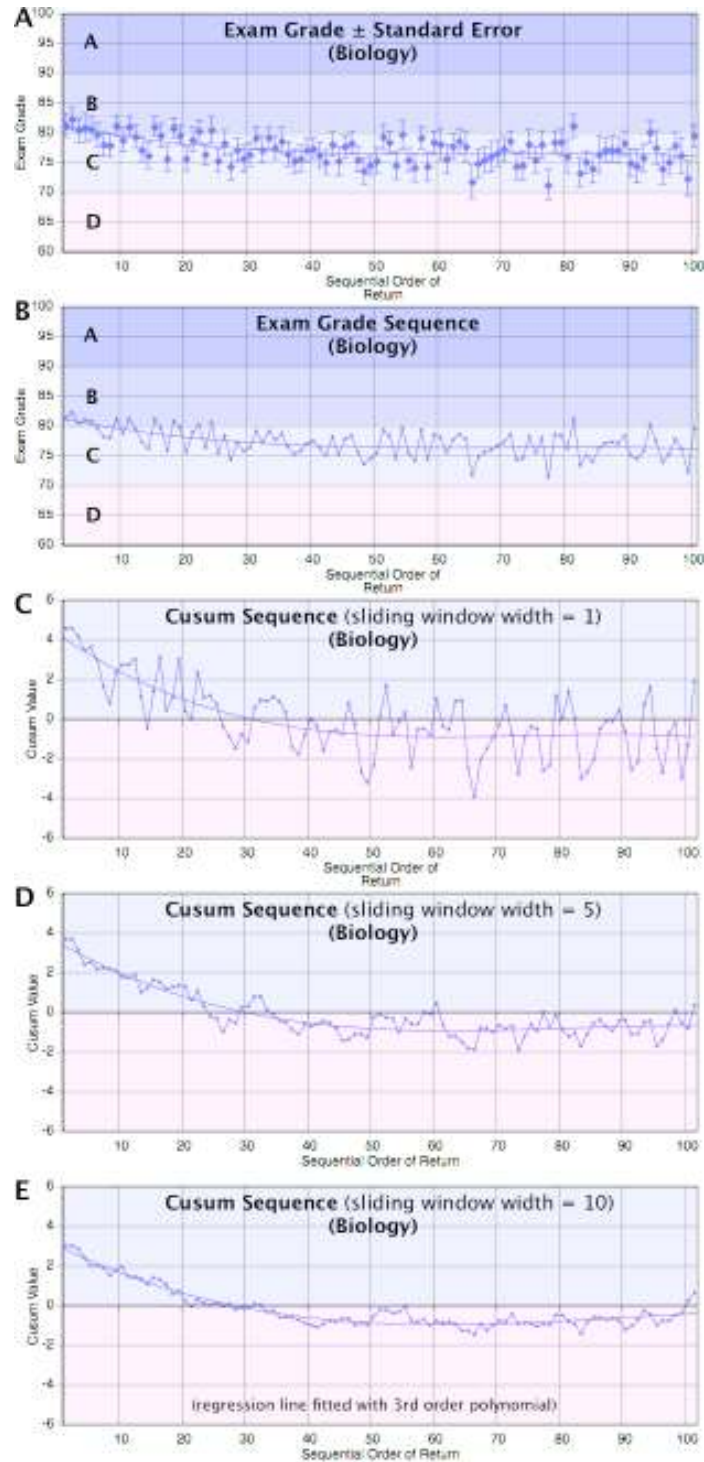**Fig. 2. The sequential order of exam grade average for the senior level neuropsychopharmacology course**

Fig. 3. The sequential order of exam grade average for the freshman level biology course
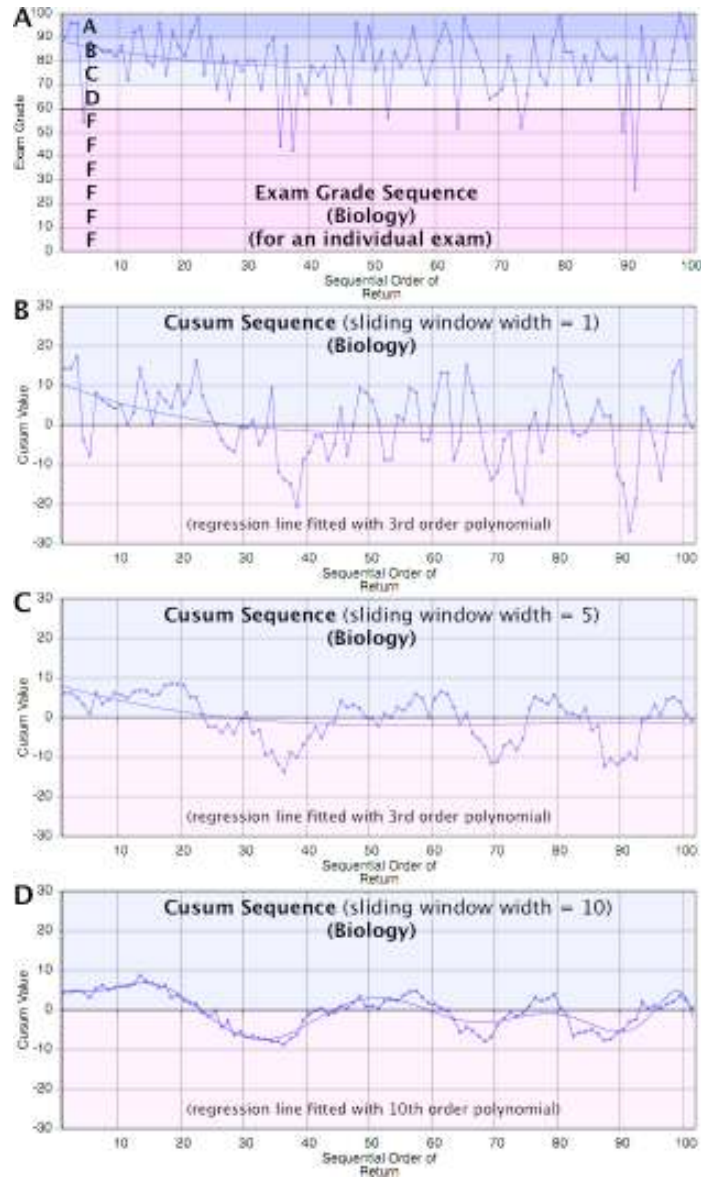
Fig. 4. The sequential order exam grade average for an individual biology course to illustrate the variability of sequential exam grades. (Regression line in Fig. 4 is fitted with a 10th order polynomial to show the variability in local trends.)

4. DISCUSSION

This study provided a quantitative scientific method to show that a statistical trend exists in the student's exam performance that is correlated with the amount of time it takes to complete the exam. Students who turned in the exam early performed 5% better on average than those students who took extra time to finish the exam. There is also a similar trend that those students who finished late until the last minute to turn in the exam are often the poorly

performing students. This is in direct contrary to the common notion that taking more time to work on an exam is associated with better exam performance, dispelling such myths for the educators and students. This finding is consistent with the outcomes in both courses, independent of the depth or breadth of materials covered.

The only difference between these two courses is that the class average is 6% higher for the advanced level course than the introductory level course. The difference in grade performance is probably due to the expertise knowledge acquired by the senior level students, or due to maturity, even though these factors are not measured in the present study. It could also be due to the highly demanding nature of the in-depth neuropsychopharmacology course, in which students are expected to have acquired the prerequisite breadth of knowledge to perform better in an advanced level course than an introductory level biology.

This is consistent with the finding that expectation, mastery and effort can affect exam performance [14,15]. The exams in the neuropsychopharmacology course tested for comprehensive knowledge — ranging from the molecular mechanisms of receptor binding by pharmaceutical agents and the involvement of neural circuitries in the genesis of psychiatric disorders to the diagnosis of the behavioral and emotional cognitive deficits in these disorders. The content of these materials requires mastery of the prerequisite knowledge in neuroscience, psychology, pharmacology and fundamental biology. Thus, the exams are not easy in any respect; yet the students consistently performed better than the introductory course by 6% on average. Nonetheless, the better-performing students tend to finish early in the exam in both levels of courses, independent of the difference in overall class average performance.

Based on the statistics, the assumption that providing students with extra time for an exam could help students to perform better is not validated with quantitative statistics. In fact, those students who turned in the exam last performed significantly worse than others. Even though such analysis is based on correlation analysis, it does not imply any causal effect — i.e., neither finishing an exam early will make better grades, nor will better students finish early. It is only a statistical relationship between early exam completion and better-performing students, given that the exam is not under limited time constraint or time pressure.

One plausible explanation for such observation is that the better-performing students are aware of the confidence that spending more time on the exam that they already know would not make it any better. On the other hand, the less prepared students may assume that mulling over the answers could help them make better grades. There are exceptions to the above, in which some failing students also turned in the exam early as shown in Fig. 4 (probably when they gave up) compared to those students who wouldn't give up (probably hoped that staying longer in the exam would inspire them to get the answers right).

This study also provided statistical evidence that the expectation/assumption that providing extra time to finish an exam without time constraints may not necessarily improve the student's performance. Thus, this dispels the myth that providing students with extra exam time is an unfair practice for other students who can finish the exam early — even though it is counter-intuitive to realize that spending more time on an exam is statistically correlated with lower grade performance. This finding also alleviates the worries and complaints that some students may have an advantage over other students, just because they were given

extra time for an exam. The extra time allotment does not necessarily provide any unfair advantage to improve their exam grade performance on average statistically.

5. CONCLUSION

This study provides a quantitative assessment of the exam performance in relation to the time it takes to finish the exam, so that educators can evaluate the appropriate allotment of time for an exam for students to perform their potentials. The data showed statistically that there is a negative correlation between exam performance and the time spent in finishing an exam. Better-performing students tend to spend less time on an exam than poorly-performing students. There is a consistent 5% point (half of a letter-grade) difference in grade performance for students who finished the exam early than those who finished late.

Highly demanding advanced level course with expected in-depth knowledge is also correlated with exam performance compared to an introductory level course by a 6%-point increase in overall class performance. But this overall better performance in the class average of the advanced level course does not affect the similar trend that students spending more time in the exam are correlated with a decrease in grade performance. This suggests that spending more time in an exam when a student already knows the answers does not necessarily help improving the grade, independent of which course the student took.

Although the statistical link between the reduction in grade performance and the time spent in an exam is established in this study, the correlation does not imply any causality that taking more time in an exam leads to poorer grade performance. Nonetheless, this quantitative study provides the statistical evidence indicating that spending more time in an exam is not linked to a better grade. On the contrary, it is link to a poorer grade. It dispels the assumption that spending extra time in an exam is related to better grade performance.

This provides the statistical evidence for educators and students to assess their decision whether providing more time in an exam than is adequate is actually advantageous to the student in improving the grade performance. If not, then it is fair to use an uniform time period for all students in an exam, provided that the exam period is adequate for most students to complete without undue time constraints to complete all the exam questions in time.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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