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Effect of a Standing Body Position during College Students' Exam: Implications on Cognitive Test Performance

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ABSTRACT

This study stems from the work of Lehman *et al.* (*Ergonomics*, 2001) which concluded that standing yields better work performance, and from the growing health trend of recommending the reduction of the amount of time spent in sitting (Owen *et al.*, *Exercise and Sport Science Reviews*, 2010). Lajoie *et al.* (*Experimental Brain Research*, 1993) provided an initial significant contribution to a theory that standing requires a person to control balance, equating to demand higher productive output from the cognitive system than when a person is sitting. An assumption was formulated that standing position during class is feasible and can be adopted on the belief that it might contribute positive results to students' performance. The purpose of this study is to identify whether a body position during exams tested along with exposure durations has a significant effect on college students' performance. Mathematical analysis and reading comprehension exam was used to measure the cognitive performance of the students. Two factors, position and duration, were tested for significance with two levels each subjected to six replicates. Twenty-four students from the College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños were randomly selected. The experiment showed that the body position during exams is a significant factor for the Math exam, but insignificant for the Reading Comprehension exam.

Keywords: Ergonomics, Design of Experiments, Sitting and Standing Position

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1. INTRODUCTION

This study initially stems from the work by Lehman *et al.* (2001), which concluded that standing yields better work performance, and from the growing health trend of recommending the reduction of the amount of time spent in sitting (Owen *et al.,* 2010). Moreover, Lajoie *et al.* (1993) provided a significant contribution that standing requires a person to control balance, thus equating to demand a higher productive output from the cognitive system than when a person is sitting. An assumption was formulated that standing position during an exam/test is feasible and can be adopted on the belief it might contribute positive results to student performance. Just like cashiers who are normally sitting during work, students during exams are in static postures and may experience fatigue which could affect their performance. The postures of students during exams are in kyphotic sitting, where the back is arched/rounded mainly due to lowering the head near towards the test paper in front of them while having an exam. Williams *et al.* (1991) stated that kyphotic sitting increases the pain in the back for subjects already suffering from back pain; which is confirmed by Harrison *et al.* (1999) that stated flexion of the lumbar spine when in kyphotic posture causes an increase of load in the disc and muscles in the lumbar spine, while lordotic posture causes a decrease of pressure. Moreover, Adams and Hutton (1983) stated that if an individual is exposed to having flexed spine, pain is most likely to develop over time. Previous studies that state lower back pain is in higher risk in sitting than in standing were made by Kroemer and Robinette (1969), Magora (1972), and Kroemer *et al.* (2001). Moreover, a study by Andersson *et al.* (1979) has proved to find benefit in standing as that posture provides a more stable lower back condition than when sitting.

Few studies, however, have tackled cognitive performance associated with posture. Studies have linked attentional demands to postural control (Lajoie *et al.*, 1993; Shumway-Cook and Woollacott, 2000; Teasdale and Simoneau, 2001; Woollacott and Shumway-Cook, 2002; Vuillerme *et al.*, 2000). However, such studies measured reaction time by the subjects as they responded from a given stimulus. Other studies (Andersson *et al.*, 2002; Maki and McIlroy, 1996) made subjects perform arithmetic tasks by counting. No studies have yet performed an experiment that involves the recruits to solve math problems and answer reading comprehension exams; most studies have their subjects measured by their reaction time or how fast those subjects can provide response/reaction based from a given stimulus, or through memory (Andersson *et al.*, 2002; Dault *et al.*, 2001). This study, however, does not measure postural control and how much postural sway is spent by a recruit when subjected to different areas of cognitive tests. Nor does this study want to test/measure the impact of the activities in the anatomy of the recruits—what it does to the lower back, spine, neck, etc. Rather this study tested whether in a real-life scenario, a different type of posture (standing) is feasible in improving the exam performance of a student.

On the average, long exams in University of the Philippines Los Baños (UPLB), specifically in College of Engineering and Agro-Industrial Technology (CEAT), last for two hours, and some would extend to three or even four hours (especially in Engineering Science courses) depending on the number of items and the difficulty of the questions and subject matter. On the average, CEAT students would encounter four long exams for one course; and for one semester, a student averages six courses. That would be an average of 24 long exams in one semester, amounting to an average of 72 hours sitting during exams in an utmost static posture.

Another variable of interest related to the position of the student during the exam is the length of exposure of the student during the exam. It has been a concern that even though standing is recommended in most workplaces, it also has its negative effects physically, especially when subjects are exposed to non-ergonomically designed environment (Lin and Chan, 2007). In addition, there are also effects mentally due to stress (Bourne and Yaroush, 2003), especially when a person is subjected to a prolonged exposure. This study, therefore, would also like to see if in the course of the examination, the effect of certain exam durations would affect the performance of the students. Longer time spent by a person induces fatigue on the lower extremities (ankles, calves) resulting in greater postural sway by a person (Yaggie and McGregor, 2002; Vuillerme *et al.*, 2002). Postural sway, however, is a natural tendency of a person to recover and do away with, or reduce the stress brought about by the posture, pointing out that perturbations are temporary and that a person can recover easily within minutes (Yaggie and McGregor, 2002). Corbeil *et al.* (2003) state that even with increased sway due to ankle fatigue, the sensorimotor system of a person is not affected and still remains efficient. In short, the *duration* factor is considered a factor in this experiment because, the 'high' and 'low' levels of a factor to carry out an experiment is recognized and shall contribute a significant output whether: 1) results from previous studies are confirmatory on a different experimental situation (in posture—both sitting and standing, and in the nature of the activity being done during the experiment), and 2) the changes in the levels of the *duration* factor provide different outcome considering the expectation of having increased cognitive attention, and efficient sensorimotor system as fatigue in the lower extremities increases due to longer duration in staying in a particular position/posture.

Most possibly, a student's lifestyle is sedentary, with previous studies conducted on college students (Leslie *et al*., 1999; Keating *et al*., 2005); because of this, students have the tendency to face weight problems such as obesity in the case of US college students as studied by Lowry *et al*. (2000) and Huang *et al*. (2003). On the average, a UPLB student spends 20 hours sitting in lecture class every week, excluding the time a student spends on studying outside class and on taking exams (which are normally done after classes). Studies conducted in Australia state that those individuals having sedentary lifestyle are more prone to experience diabetes, obesity and cardiovascular diseases (Hu *et al.*, 2001, 2003; Healy *et al.*, 2008). Thus, it recommends that organizations consider sedentary work as an emerging health issue and further recommends reducing the amount of time spent in sitting (Owen *et al.,* 2010). This study takes into consideration that factor, along with the issue of possible occurrence of back pains to students due to prolonged exposure to sitting.

However, this study is mostly concerned with the application of a new style for students during exams: standing. Since design of experiment can test altogether two or more factors, the experiment would also want to find out the effect of sitting and standing on a student when altogether exposed to different levels of exam duration. Therefore, this study aims to assess the cognitive performance of students during an exam given two factors: the position and the duration of taking the exam, specifically doing a 2^2 factorial design experiment with six replicates.

Two sections of exams are used: mathematical analysis and reading comprehension, for the purpose of providing a field of study which every student may be able to answer; in this case, Engineering. Most common domains of intelligence, the intellectual strengths, as Gardner (1985, 2003) state, are the linguistic and the logical-mathematical. The educational system in this case study involves a University that caters to students who are linguistically and logical-mathematically intelligent at the same time, even if the samples of engineering college students are presumed to be more logical mathematically intelligent than being linguistically intelligent, considering that the nature of engineering is leaned towards mathematically-heavy. The mathematical analysis and reading comprehension exams are, therefore, applicable for the sample/recruits since most of the basic questions reflect what and how the University educational system provides in a normal student assessment exercise. A general mathematical analysis and reading comprehension exam will mimic the normal manner of assessing the students' performance. The nature of engineering is mostly based on physical and mathematical sciences and their application; therefore, it is already assumed that the recruits are in the comfort zone of answering the Math section in the experiment. Reading comprehension exam was still chosen to be a subject to be used in this experiment because scholarly students are ideally expected to be holistically competitive in almost all areas of intelligence; therefore, it is mandatory that these students should provide effort in developing this domain of intelligence. This format of having these two different subjects in the experiment is fitting, most especially if this experiment is to be carried out on different recruits, such as students taking Fine Arts, Medicine, Business, Law, etc.

The factors that have been identified are *position* and *duration*, each with two levels. Moreover, the response variables are the mean scores of the students from the Math and Reading Comprehension, measured separately. Combining all of these, a design of experiment is to be done to see whether position and/or duration have significant implications on student exam performance.

The null hypothesis for the *position* main effect is that mean Math score of sitting and standing students is equal; with an alternative hypothesis that mean Math score of sitting students is different from standing students. The same applies to the *position* main effect null and alternative hypothesis for the Reading Comprehension exam. For the *duration* main effect, the null hypothesis is that mean Math scores of students taking a 2-hour exam is equal to those students taking a 4-hour exam. The alternative hypothesis is that mean Math scores of the students taking the 2-hour exam is not equal to the mean Math scores of the students taking the 4-hour exam. The same applies for the *duration* main effect null and alternative hypothesis for the Reading Comprehension exam. For the interaction effects, for both the Math and Reading Comprehension, the null hypothesis is that there is no *position* and *duration* interaction. On the other hand, the alternative hypothesis is that *position* and *duration* have interaction effects.

The decision rule for the statistical tests was to reject the null hypothesis if p-value is less than $\alpha = 0.05$; and fail to reject null hypothesis otherwise. When the null hypothesis is rejected, the source of variation (main effects and interaction effects) being tested is then regarded as 'significant'.

2. METHODOLOGY

In setting up the experiment, the factors considered were: position and duration of taking exam. Two levels were used for both factors; for the former, sitting (low) and standing (high), and for the latter, two hours (low) and four hours (high). This experiment was done with six replicates per run. The response variables for this study were identified to as the average scores of the student in the Math and Reading Comprehension exams. A student was used only once during the experiment, thus a student took the two exams in one run.

One set of identical exams was used for those taking the 2-hour exam, and another identical set of exams was used for those taking the 4-hour exam. The set of exam for the 4-hour duration included the same set of 2-hour exam plus an additional set of questions good for another 2 hours but with the same level of difficulty as with the former 2-hour exam. The 2-hour exam was composed of four sections (two sections for Math and two for Reading Comprehension, alternating each other). The 4-hour exam was composed of eight sections, with the identical four sections used from the 2-hour exam, plus another four new sections (two sections each of Math and Reading Comprehension, alternating each other). Each section was good for 30 minutes.

The tables used for the experiment were designed in a way that they can be adjusted to the examiners' height. However, since this study is not dealing with optimization design, the table was set to 39 inches in height, well within the range set by Cohen (1997), which was 34 to 43 inches, encompassing both the 'precision' and 'light' work.

Students who participated in the experiment were registered students of the current 2nd semester of academic year 2011–2012 of the CEAT, UPLB. Their participation was voluntary, with students invited to participate in the study through a letter given directly to them. These shortlisted students came from the initial list of eligible students falling in the highest general weighted average (GWA) category, which was requested from the College Secretary's Office. Among the 43 shortlisted students, 28 students confirmed voluntary participation, but later was reduced to 24 because of conflicts in their schedule, still just right for the needed number of volunteers because of the planned six replicates.

The students were randomly selected from a pool of Engineering students who have a GWA of 1.45 or better in the previous two semesters. The reason behind this was to separate and group the eligible engineering students based on the level of intellectual ability. The results of the experiment must reflect the effect of the position and duration factors; therefore, the intellectual ability factor needs to be eliminated. As a result, the students with the same intellectual ability are grouped together and selected to participate in the experiment; differences between are deemed insignificant; to provide assurance that the resulting differences in the scores in the exam are brought about by the tested factors (position and/or duration) and not about by the intellectual ability of the students.

There was only one scheduled date for the exam on this experiment. The schedule of the exam for each student was randomly assigned and each student was informed of their respective schedules. It was assumed that the students are in good mental and physical condition when taking the exams. The students were briefed about the experiment and what to expect during the experiment. The students were all aware that they will be randomly assigned to sit or stand for 2 or 4 hours taking a Math and Reading Comprehension exam. The students were only asked to bring their own ballpen during the experiment. The students were provided with scratch papers and answer sheets. The test questionnaires were proof-read and the answers validated, and assured that every test booklet includes complete number of pages and sections.

One student was considered one run. The students took the exams simultaneously, since each student is independent with each other: the result generated of one student does not affect the results of the other students. The experiment was done only in one location: ergonomics laboratory, where both the sitting and standing position in 2- and 4-hour durations were simultaneously tested.

The exams were manually checked, and the percentage scores were recorded for Math and Reading Comprehension separately. The results of the exams were further inputted into Minitab 16 (statistical software) and the factorial design was analyzed using this software. A full 2^2 factorial design was used with 6 replicates.

3. RESULTS AND DISCUSSION

Table 1 shows the results of the exams for both Reading Comprehension and Math. Table 2 shows the ANOVA table for Reading Comprehension, and Table 3 shows the ANOVA table for Math. Effect A is the position of the student during exam (sit, stand), and B is the duration of the exam (2-hour, 4-hour); A×B stands for the two-factor interaction.

Table 2 shows that none of the effects and interaction is significant using $\alpha = 0.05$, which just means that the mean score of those who took the Reading Comprehension exam in a sitting position is equal with those who took the exam in standing position. Moreover, the same analysis applies to the duration—mean scores of the two levels are equal. In addition, since null hypothesis is failed to be rejected, it can be concluded that there is no interaction effects of *position* and *duration* for the Reading Comprehension exam

Table 3 shows that only Effect A (position) is significant using $\alpha = 0.05$, which further means that the mean

Table 1. Results of the experiment

Run#	Standing order	Position	Duration (hr)	Math	Reading
1	14	Stand	2	92.5	54.55
2	17	Sit	2	70	27.27
3	21	Sit	2	77.5	39.39
4	16	Stand	4	91.25	80.3
5	1	Sit	2	70	60.61
6	6	Stand	2	62.5	39.39
7	12	Stand	4	78.75	50
8	13	Sit	2	77.5	45.45
9	18	Stand	2	65	33.33
10	19	Sit	4	65	39.39
11	15	Sit	4	68.75	46.97
12	4	Stand	4	78.75	31.82
13	10	Stand	2	85	51.52
14	24	Stand	4	65	42.42
15	8	Stand	4	90	28.79
16	7	Sit	4	77.5	50
17	23	Sit	4	65	66.66
18	20	Stand	4	81.25	43.94
19	3	Sit	4	61.25	27.27
20	22	Stand	2	80	45.45
21	9	Sit	2	62.5	45.45
22	5	Sit	2	60	42.42
23	2	Stand	2	75	48.48
24	11	Sit	4	82.5	63.64

Table 2. ANOVA table for reading comprehension

Source	DF	SS	MS	*F*	*p*-value
A	1	0.86	0.86	0.005	0.946
B	1	59.82	59.82	0.324	0.576
A×B	1	34.54	34.54	0.187	0.670
Error	20	3,696.66	184.833	-	-
Total	23	3,791.87	-	-	-

Table 3. ANOVA table for math

Source	DF	SS	MS	*F*	*p*-value
A	1	481.51	481.51	5.563	0.029
B	1	31.51	31.51	0.364	0.553
A×B	1	21.09	21.09	0.244	0.627
Error	20	1731.25	86.5625	-	-
Total	23	2265.36	-	-	-

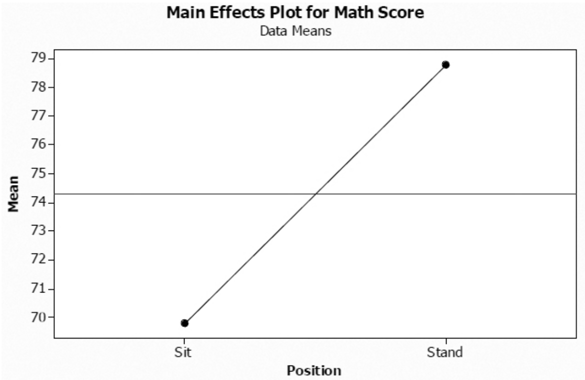

Figure 1. Position effect plot of math scores.

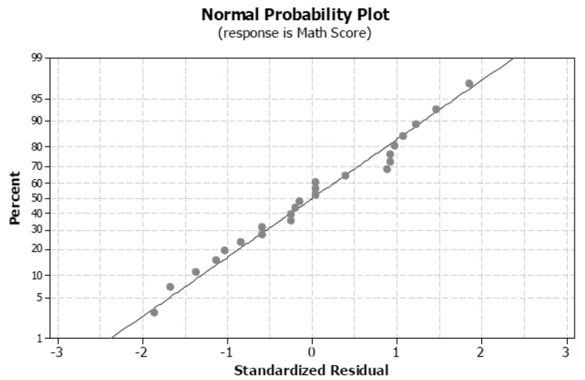

Figure 2. Normal probability plot of Math scores.

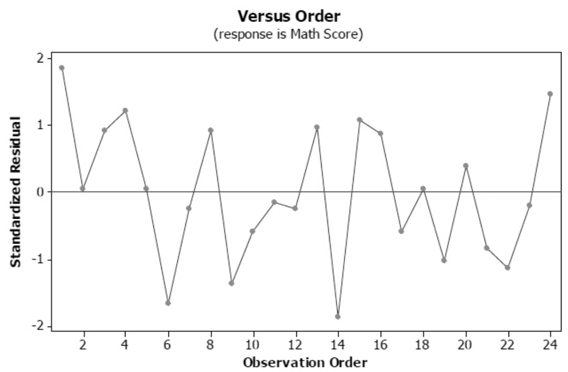

Figure 3. Residuals vs. run order of math scores.

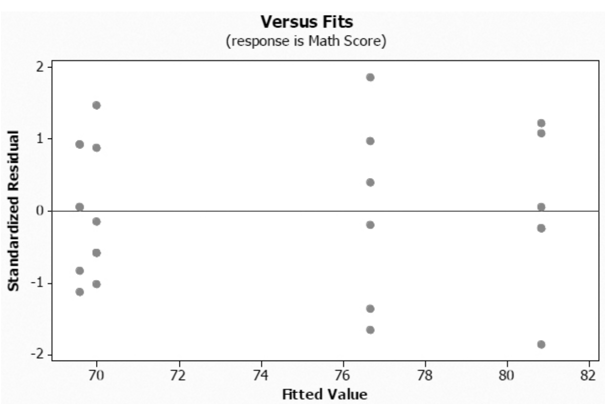

Figure 4. Residuals vs. fit order of math scores.

score of those who took the Math exam in a sitting position is significantly different with those who took the exam in standing position. Figure 1 shows the main effect plot of *position* whereby the mean Math score when standing is higher than the mean Math score when sitting.

Diagnostic plots for both ANOVA are presented to see whether assumptions are met, whereby Figures 2–4 show the normal probability plot, residuals vs. run order, and residuals vs. fits, respectively for the Math exam. The normal probability plot (Figure 2) shows that almost all the points lie along the line with very few departures. The number of observations is only 24, which explains the slight curvature of points that appear in the illustration. Overall the residuals from this analysis are normally distributed. In Figure 3, the residuals fluctuate in a random pattern around the center line (zero). Even though runs were administered altogether, the plot still gave an indication of randomness; moreover, there is no existing evidence that the residuals are correlated with one another. In Figure 4, the residuals are scattered randomly around zero. No patterns such as megaphoning or funnel-like image exist as the fitted values increase. Therefore, there is no evidence to say that non-constant variance exists.

4. CONCLUSION

This study took on the challenge to see if the exam performance of engineering students is affected by the position and/or duration of the exams. The striking difference of this approach compared to other previous studies dealing with the implications of standing posture is that the work being done by the recruits involves mental processing and is not just office-related and repetitive. Previous studies by Lin and Chan (2007) and Lehman *et al*. (2001), for example, show workers in a factory environment for the former, and cashier in a checkout counter for the latter; whereby office/work setting is highly repetitive and does not highly involve intellectual reasoning and analysis. This study also breaks the normal situation of a student's position during exam, and suggests that a nonconventional posture, which is standing, is feasible and can even produce better exam results.

This study also highlights a major contribution to the health concerns regarding excessive sitting among people. Studies have shown recommending more people to avoid sitting over long duration because of the negative effects it can bring. This study highlights the recognition that more and more students are becoming sedentary which tends to attract negative health effects into their system. The standing during exam option, therefore, provides a good alternative to consider as it not just promotes continuous active body functioning for better health but also great cognitive performance as well.

This study has not only attested the hypothesis that people are equally or even more productive and effective when standing. It is also interesting to note that position is a significant factor for the Math exam, whereby students who took the exam in a standing position yielded higher scores in Math than those who were sitting down. The population the sample represents is the engineering students, particularly in CEAT of UPLB, in which solving math and its application is the main forte of its students. Possible explanation is that when students are in a standing position, they have more opportunity to move than when in sitting position. This natural mode of the human body to move and transfer weight from one foot to the other (during standing), or one sit bone to another (during sitting) is the postural sway. During the study, the subjects were not instructed to freeze and maintain a certain posture. The subjects were left free to do just what a normal student acts, reacts, moves, etc., when taking an exam—another unique point about this study. Even though this study does not measure the postural sway of the subjects, it was evident from observation that the subjects that were standing have more postural sway compared to those subjects assigned to the sitting position.

The results of this study received confirmation from previous studies that postural control is affected when the subjects are provided/loaded with cognitive tasks (Maylor *et al.*, 2001; Morris *et al.*, 2000; Pellecchia, 2003; Rankin *et al.*, 2000; Redfern *et al.*, 2001), and that people generally avoid static positions for prolonged periods, thus even if the person is just standing or sitting, it is expected to see frequent movements (Harrison *et al.,* 1999)

Two important conclusions are drawn from the results: 1) because subjects in the standing position have greater space for movement to cater for the need for postural sway, they were able to maintain a healthy posture to fight off the discomfort and other health challenges; the subjects that were in a sitting position are limited in movement because of the chair with arm rests and a writing pad, thus postural control is limited, which can cause discomfort; and 2) this confirms that attentional demand required during standing is greater than when sitting (Lajoie *et al*., 1993; Pellecchia, 2003; Vuillerme *et al*., 2002) because the subjects in standing are required to think and answer the questions on the exam and at the same time maintain balance. The results can be considered significant enough for the fact that the subjects in standing scored higher than those subjects in sitting—because in the first place, those subjects in standing position have the more difficult situation in the experiment that required them not only to be physically strong but also mentally.

The standing position is also thought to provide the students good flow of blood circulation—especially as Shvartz *et al*. (1980) state that poor circulation of blood to the legs is experienced by a person sitting on a chair because of the compression of the veins in the thighs and hips. Taking everything into account, it is believed that since subjects that were standing are thought to have more postural sway, they are also believed to have adjusted their posture to provide themselves comfort during the task thus possibly making them less stressed. Those students that are in the sitting position are believed to have limited space, thus limited opportunity for postural control, which further provides an increase in discomfort and stress. People sitting in chairs require the opportunity for a change in position (Branton, 1969); but in the experiment with the subjects in the sitting position, the situation they are in does not provide them the opportunity to change in position—with only the legs and feet as the body parts that can move drastically while their buttocks are glued to their seats.

Most importantly, with the stresses the students are experiencing during exams (Bourne and Yaroush, 2003), it would be advisable to recommend measures on minimizing their effects as cognitive performance of college students are affected. And since standing position provides available space and opportunity for movement than with sitting position, the subjects in standing position during the exam may have performed better in Math because of the minimized stress they have experienced. These are just possible explanations which may be further proven with research specifically addressing those hypothesized causes.

The results in Reading Comprehension, however, can also be taken positively. In fact, the Reading scores were found to be statistically equal to each other for the duration and the position effects, which is quite good. At least the analysis did not turn out to be significant only to show that scores are lower in standing than in sitting.

5. AREAS FOR FURTHER STUDY

It is recommended that this study be continued further on students from other colleges in the university, since other fields of study may be inclined to a more linguistically-intelligent, such as those students majoring in Law, Medicine, Philosophy, etc., unlike the sampled recruits used in this study which is logical-mathematical (in the Engineering field). However, it is still recommended to group the recruits based on the level of intellectual abilities such that the results coming from those students can be compared to each other—results based not in the difference in intellectual capability.

Another recommended approach is to use actual examination situation based on the current subjects/courses being studied by the students, to intensify the need for the students to perform naturally at their best. However, proper controls must be observed, such as segregating/grouping the students based on intellectual capability and their exam results can only be compared among themselves (within the group) and not to other results from students who belong to other level or group with a lower/higher level of intellectual capability. The set-up for the experiment may be very intricate so as to always provide one group that will be able to take the exam on a seated position, and the other on a standing position—

noting that these two groups are of the same level of intellectual capability.

In addition, since students come and go inside a classroom, and anyone can use the table that will be shared with other students of different heights, adjusting the table is not appropriate for use. Therefore, it is further recommended that a separate study be performed focusing on the optimization of the workstation configuration to fit most students' needs inside the classroom.

Another recommendation for further studies is to bring the experiment on for a long-term basis, trying to see if students can produce better performance even if standing during class, lecture sessions; not just during examination periods. Moreover, it is also recommended that a feasibility study be conducted on building classroom and table types that would facilitate a friendly standing environment for the students while attending a lecture, recitation, and/or laboratory class.

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