RESEARCH ARTICLE

# Retention of basic and clinical concepts in Anatomy and the effect of multiple testing

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**ABSTRACT**

**Background:** Clinical competency depends on student's knowledge of basic sciences including the learned concept in Anatomy. But what if students forget the learned knowledge of human anatomy?

**Objectives:** This research investigated knowledge gain post instruction, knowledge retention (or loss) of basic and clinical concepts five months after. It also compared the effect of delayed-multiple testing and delayed-single testing in the retention of acquired knowledge.

**Methodology:** This is an experimental study conducted among first year medical students who underwent neuroanatomy module and later followed-up after five months using a 32-item test-retest. Items were categorized as basic knowledge and clinical correlation. Participants were randomly assigned into two groups; delayed-multiple and delayed-single testing. Mean difference in scores between the 2 testing periods (end-of-module and terminal delayed test) were analyzed using paired samples t-test while mean difference between basic and clinical correlation were analyzed using independent samples t-test. The degree of knowledge loss was determined using the computed Knowledge Loss Percentage (KLP).

**Results:** Knowledge gain was noted at the end of instruction (*p value<0.001*). Knowledge loss is higher among basic knowledge (*p value<0.001*) and demonstrated a higher computed KLP. Repeated testing demonstrates a higher retention (KLP=4.34) compared to those administered with a single test only (KLP=26.73).

**Conclusion:** Knowledge loss occurs post instruction and more pronounced among basic concepts. Clinical correlation and frequent testing demonstrate a significant retention capability. To reduce the effect of knowledge loss among basic concepts, this study recommends the implementation of multiple testing.

**Keywords:** *knowledge loss, clinical correlation, assessment*

## Introduction

Human Anatomy remains to be a foundation subject in basic medical education. Clinical competency rely on the student's knowledge of basic sciences. A student who passed the course is assumed to have acquired the minimum required knowledge in the subject matter relevant to the practice of the medical profession. These include the ability to recognize anatomical problems and point-out structures involved, given a hypothetical or actual case encounter and laboratory or radiographic images. Also, the student should able to execute physical examination and other standard medical procedures using the concepts of surface anatomy. These sets of competencies are needed by a future practicing doctor so that he/she can adequately examine the patient in order to arrive at a probable diagnosis, and at the same time, come up with the appropriate management.

In 2016, the Philippine Commission on Higher Education (CHED) released the new Memorandum Order (CMO) No 18: Policies, Standards, and Guidelines for the Doctor of Medicine Program. CMO 18 mandate all medical institutions to shift and implement the outcome-based education in the delivery of the curriculum in response to identified glaring gaps in the health care system [1]. This paradigm shift had led to different approaches in teaching basic sciences, including Anatomy, that would ensure and contribute to the achievement of the defined CMO Learning Outcomes. Medical schools are now geared in teaching the subject matter with more focused on correlating the basic concepts to its future clinical application. These now leads to raise questions among Anatomists as to whether teaching clinical correlation concepts are long-lasting as compared to basic knowledge.

As the medical student moves to the second level of the curriculum, they are all pre-occupied with the concepts of the new courses. The high demands of the advanced subjects prevent them from going back to the previous basic sciences to achieve high grades. Though some faculty are making an effort to review past concepts, this is not always the case. Due to the assigned limited time to deliver the instruction, they are but forced to focus on the current content of their assigned topic. Furthermore, assessments are no longer aimed to measure past knowledge, but the focus is on the current topics/subject matter. In effect, acquired knowledge in basic sciences slowly decays and forgotten. “Students don't know their Anatomy,” is a common anecdotal expression of clinical consultants, and more often, they are dismayed each time they probe questions to 3rd or 4th year medical students during patient rounds, endorsements, and other teaching activities related to the clinics. These now translate to poor patient care.

Evidence revealed that only two-third to three-fourth of acquired knowledge in basic sciences is retained after one year, and a sizeable proportion of basic science knowledge is retained despite a prolonged retention interval [2,3]. There is a decline of anatomy recall during the pre-clinical years; however, adequate storage of anatomical knowledge in the memory bank and clinical reinforcement plays an essential role in enhancing its storage [4]. Knowledge loss is not an exclusive phenomenon in the anatomy course. Other core basic sciences like Physiology or Biochemistry were found to have knowledge decay during the clinical years of medical education. A study among fifth year medical students scored lower on basic sciences questions while obtaining a higher score on the clinical items [5]. A possible explanation to this is that students in the clinical years are overwhelmed by the numerous clinical data and concepts and slowly lose their insight into the basic knowledge.

The use of progress or multiple testing is now gaining popularity among medical institutions. It is believed that re-exposure to the learned material in the form of testing, allows retrieval of information from remote memory and strengthens that information from the memory bank, hence leading to better long-term retention [6]. A study by Larsen *et al.* [7] shows that giving of repeated testing with feedback, result in higher knowledge retention when information is retrieved 6 months after instruction. Additionally, interactive sessions and clinical correlation might not be sufficient simply because these interventions focus only on improving initial learning. Thus, repeated testing is necessary to facilitate retrieval practice, hence improving knowledge retention [7]. Repeated testing produces more knowledge retention compared with the repeated study. Thus, test administration should be regularly spaced out in time to enhance better knowledge retention.

This research investigated the extent of knowledge gain between basic and clinical correlation concepts in Anatomy post-instruction and knowledge retention (or loss) between end-of-module exam and final delayed test for both basic and clinical concepts. This study also compared the effect of delayed-multiple versus delayed-single testing intervention in the retention of acquired knowledge five months post-instruction.

## Methodology

To determine the knowledge retention and the effect of multiple testing, an experimental study was conducted among first year medical students. A total of 307 1st year medical students enrolled in Anatomy qualified initially for the study. Non-signage of the informed consent, failure in anatomy course at the end of the school year and non-promotion to second year are among the exclusion criteria. Two hundred twenty five students were able to complete the study. The participants were asked to answer a similar test in three time periods (*i.e.*, at the start of the module (pretest) at the end of the module (end-of-module test) and 5 months after the administration of the end-of-module test (delayed test). The test items were formulated from a test blueprint and each question was categorized according to question level (basic knowledge or clinical correlation). A standardized 32-item exam tool was used in this research project and was formulated from a test blueprint. Four stages were involved in the development of the exam. **Stage 1:** Formulation of the test items by the researcher that matches the test blueprint. **Stage 2:** The content validity survey was conducted to ensure the content validity of the instrument. Five (5) experts were invited to review the question items. Reviewers were asked to rate each item and determine whether the item matches the blueprint's construct and content using the Likert Scale 1-5. Items with Content Validity Ratio (CVR) of 0.99 and lower was removed and replaced with new question item. Wordings was changed based on the suggestion of the reviewers. **Stage 3:** Revised items were sent back to the reviewers for a secondround rating to ensure the validity of the formulated tool. **Stage 4:** The exam was pilot tested among selected medical students. Student feedback, comments, and suggestions were applied. For this study, the neuroanatomy topics were chosen as the representative module. Knowledge of the anatomical concepts was determined by the test scores achieved by the participants at each testing point. The study was approved by the Ethics Review Board of the De La Salle Medical and Health Sciences Institute before its implementation.

In the first phase of the study, all participants were administered the initial test at the beginning of the neuroanatomy module. After going through the module, the participants were administered the same test administered during the pretest. In the second phase of the study, students who were promoted to level 2 were permitted to continue to participate. The qualified participants were randomly assigned into two groups, 113 was assigned to the delayed-multiple testing arm and 112 to the delayed-single testing group. For the delayed-multiple testing group, the selected students were tasked to take three tests with the first test administered at the beginning of the school year, then with an interval of 4 weeks after that. The test items were the same questions used during the pre-test and end-of-module exam. The three tests were administered unannounced and scheduled during their free time. On the other hand, the single testing group was tasked to take just one exam, which coincides with the 3rd testing of the initial group.

Mean scores of the three different tests were computed and subjected to statistical analysis using the Microsoft Excel Analysis ToolPak add-in. Paired samples t-test set at 95% confidence interval and an alpha error of 0.05, was used to compare the level of significance on the mean scores between two testing intervals, (1) pretest and end-of-module test, (2) end-of-module test and final delayed testing. Furthermore, the mean scores difference between multiple and single testing group was analyzed using independent samples t-test set at 95% confidence interval and an alpha error of 0.05. T-distribution was used to determine the p-value as the level of significance. Moreover, the degree of knowledge loss was determined using the computed Knowledge Loss Percentage (Figure 1).

## Results

A total of 225 medical students were able to participate in this study. Among the 225 included students in the study, 88 (39.11%) are males, and 137 (60.89%) are females. Twenty-seven students (12%) are from the accelerated courses taking up BS Human Biology, Medical Biology, and Biochemistry and 205 (88%) are graduates of different baccalaureate programs. Six among the 225 participants are foreigners (Table 1).

*Result of Pretest, End-of-Module and Final Delayed Test*

Paired samples t-test analysis (Table 2) for the pretest (6.97 ±0.468) and end-of-module (18.21 ±0.668) shows a significant increase (*p<0.001*). Comparison of end-of-module (18.21 ±0.668) and final delayed test (15.36 ±0.755) shows a significant decline (KPL=15.65%) in the overall scores (*p<0.001*). In terms of knowledge level (Table 3 and Figure 2), there was a significant

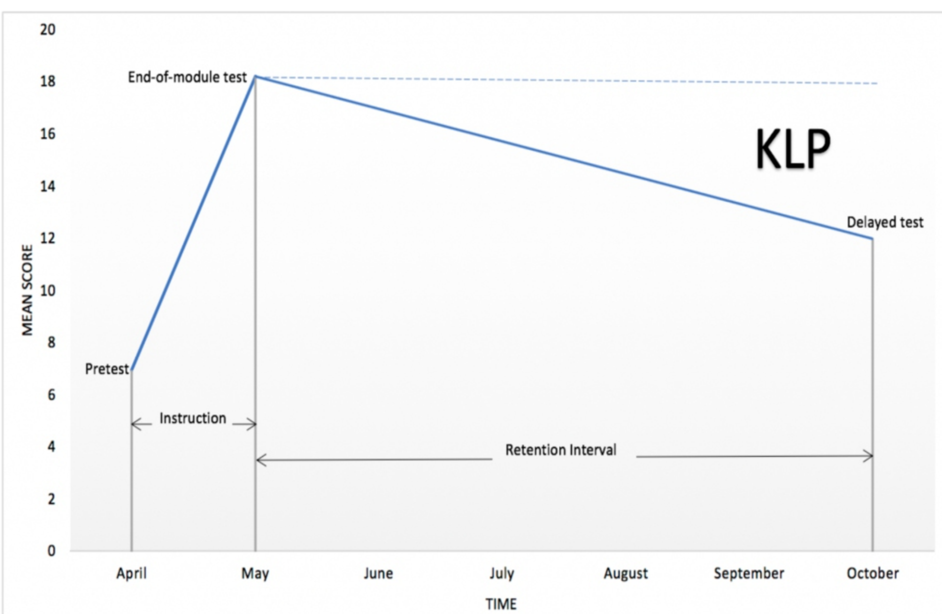


**Figure 1.** *Knowledge loss percentage determination during the period of retention interval*

**Table 1.** *Distribution of respondents according to gender, course, nationality and group assignment*

| Demographics | | Total | Multiple Testing Group (113) | Single Testing Group (112) |
|---|---|---|---|---|
| Gender | Male | 88 (39.11%) | 46 (40%) | 42 (38.18%) |
| | Female | 137 (60.89%) | 69 (60%) | 68 (61.82%) |
| Course | Regular BS | 198 (88%) | 100 (88.5%) | 98 (87.5%) |
| | Accelerated | 27 (12%) | 13 (11.5%) | 14 (12.5%) |
| Nationality | Filipino | 219 (97.33%) | 109 (96.46%) | 110 (98.21%) |
| | Foreigner | 6 (2.67%) | 4 (3.54%) | 2 (1.79%) |

**Table 2.** *Paired and independent t-test comparison of overall mean scores of pretest, end-of-module and final progress tests and according to question level*

| | Pairs | Mean Score | N | t | Sig |
|---|---|---|---|---|---|
| Paired T-test | Overall Total Score (pretest)<br>Overall Total Score (end-of module) | 697<br>18.21 | 225 | -34.335 | 0.000 |
| | Overall Total Score (end-of-module)<br>Overall Total Score (final delayed test) | 18.21<br>15.36 | 225 | 7.574 | 0.000 |
| | Total Score-basic knowledge (pretest)<br>Total Score-basic knowledge (end-of module) | 3.39<br>10.43 | 225 | -35.895 | 0.000 |
| | Total Score- basic knowledge (end-of-module)<br>Total Score- basic knowledge (final delayed test) | 10.43<br>7.93 | 225 | 11.763 | 0.000 |
| | Total Score-clinical correlation (pretest)<br>Total Score- clinical correlation (end-of module) | 3.58<br>7.78 | 225 | -21.898 | 0.000 |
| | Total Score-clinical correlation (end-of-module)<br>Total Score-clinical correlation (final delayed test) | 7.78<br>7.43 | 225 | 1.638 | **0.103** |
| Independent T-test | Total Score-basic knowledge (pretest)<br>Total Score-clinical correlation (pretest) | 3.39<br>3.58 | 225 | -0.963 | **0.336** |
| | Total Score-basic knowledge (end-of module)<br>Total Score-clinical correlation (end-of-module) | 10.43<br>7.78 | 225 | 9.874 | 0.000 |
| | Total Score-basic knowledge (final assessment)<br>Total Score-clinical correlation (final delayed test) | 7.93<br>7.43 | 225 | 1.717 | **0.087** |

increase in the basic knowledge pre-test mean score (3.39 ±0.265) and end-of-module test mean score (10.43 ±0.362); (*p<0.001*). Similarly, a significant increase noted in the clinical correlation pre-test mean scores (3.58 ±0.284) and end-of-module test mean score (7.78 ±0.382); (*p<0.001*). Furthermore, a significant decrease in mean score noted between the basic knowledge end-of-module test (10.43 ±0.362) and final delayed test (7.93 ± 0.435); (*p<0.001*). However, mean score difference between clinical correlation end-of-module test (7.78 ±0.382) and final delayed test (7.43 ±0.38) is not statistically significant (*p=0.103*). KLP for basic knowledge is 23.97% and 4.50% for clinical correlation.

Independent samples t-test (Table 3 and Figure 2) was conducted to compare the mean scores of basic knowledge and clinical correlation questions. There was no significant difference in the baseline pre-test scores for both basic knowledge (3.39 ±0.265) and clinical correlation (3.58 ±0.284); (*p=0.336*). However, post-instruction, there was a significant difference in the mean score of basic knowledge (10.43 ±0.362) and clinical correlation (7.78 ±0.382) during the end-of-module exam; (*p<0.001*). Lastly, the difference of basic knowledge (7.93 ±0.435) and clinical correlation (7.43 ±0.38) in the final delayed test is not statistically significant; (*p=0.087*).

*Multiple and Single Testing Result*

For both groups (Table 4), a significant increase in the overall mean score was noted from the baseline pre-test (multiple testing [6.88 ± 0.71], single testing [7.07 ±0.609]) and end-of-module exam (multiple testing [17.95 ±0.896], single testing [18.48 ±0.993]); multiple testing (*p<0.001*); single testing (*p<0.001*). For single testing, a significant decrease in mean score was noted from the end-of-module (18.48 ± 0.993) to delayed test (13.54 ±1.05); (*p<0.001*), and a non-significant mean score difference between end-of-module (17.95 ±0.896) and delayed test (17.17 ±0.975) for the multiple testing group; (*p=0.097*). KLP for the single test group is at 26.73% and for multiple tests group is 4.34%.

Comparison of mean scores of the group provided with multiple tests and group with only a single test according to question-level using paired samples t-test (Table 4, and Figure 3). For basic knowledge, both groups showed a significant increase in end-of-module mean score (multiple test [10.44 ± 0.454], single test [10.42 ±0.556]) from the baseline pretest (multiple test [0.42 ± 0.562], single test [3.57 ±0.372]); multiple test and single test (*p<0.001*). For clinical correlation, significant increase from pretest ([3.66 ±0.43], single test [3.5 ±0.372]) to end-of-module test (multiple test [7.5 ±0.54], single test [8.06 ±0.537]) was observed for both groups; multiple test and single test (*p<001*). For the comparison of mean score between end-of-module and delayed test for the four subgroups, significant decline in the test score (8.86 ±0.572) for basic knowledge, delayed-multiple testing; (*p<0.001*), and test score (7 ±0.613) for basic knowledge, delayed-single testing, (*p<0.001*). A significant decline in the test score for clinical correlation, delayed single testing (6.54 ±0.526); (*p<0.001*), but a significant increase in test score for clinical correlation, delayed multiple testing (8.31 ±0.502); (*p=0.005*). Computed KLP in basic knowledge for single test is 32.82% and 15.13% for multiple test while computed KLP in clinical correlation for single test is 18.86% and 0% for multiple test.

As a baseline, analysis using independent samples t-test (Table 4, Figure 3)shows a non-significant difference between the basic knowledge group in mulitple testing (10.46 ±0.454) and basic knowledge group in single testing (10.42 ±0.567); (*p=0.951*). Also, no significant difference in mean scores between clinical correlation in multiple testing (7.5 ±0.54) and single testing group (8.06 ±0.537); (*p=0.152*). In the final assessment, the highest-scoring is the basic knowledge-multiple testing group (8.86 ±0.572) and comparison with a clinical correlation-multiple testing group (8.31 ±0.502) shows a non-significant difference (*p=0.159*). On the other hand, clinical correlation-single testing (6.54 ±0526) has the lowest score in the final assessment in comparison with basic knowledge-single testing (7 ±0.613) shows a non-significant

**Table 3.** *Paired and independent t-test comparison of total mean scores of pretest, end-of-module and final progress tests according administration of multiple testing and single testing*

| | Pairs | Mean Score | N | t | Sig |
|---|---|---|---|---|---|
| Paired T-test | Total Score-multiple testing (pretest)<br>Total Score-multiple testing (end-of module) | 6.88<br>17.95 | 113 | -24.344 | 0.000 |
| | Total Score- multiple testing (end-of-module)<br>Total Score- multiple testing (final delayed test) | 17.95<br>17.17 | 113 | 1.673 | 0.097 |
| | Total Score-single testing (pretest)<br>Total Score- single testing (end-of module) | 7.07<br>18.48 | 112 | -24.143 | 0.000 |
| | Total Score-single testing(end-of-module)<br>Total Score-single testing (final delayed test) | 18.48<br>13.54 | 112 | 9.412 | 0.000 |
| Independent T-test | Total Score-multiple testing (pretest)<br>Total Score-single testing (pretest) | 6.88<br>7.07 | 113<br>112 | -0.409 | 0.683 |
| | Total Score-multiple testing (end-of module)<br>Total Score-single testing(end-of-module) | 17.95<br>18.48 | 113<br>112 | -0.784 | 0.433 |
| | Total Score-multiple testing (final delayed test)<br>Total Score-single testing (final delayed test) | 17.17<br>13.54 | 113<br>112 | 4.995 | 0.000 |

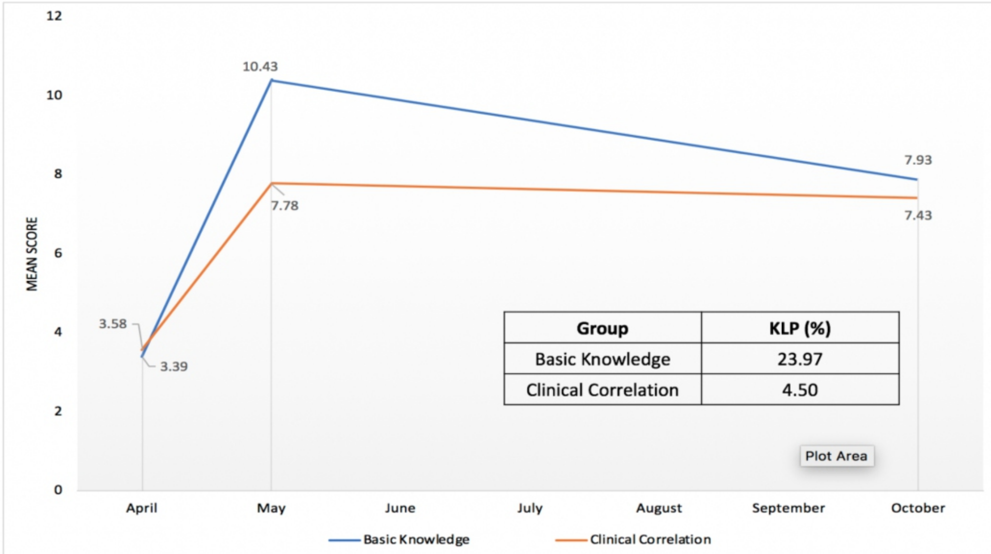


**Figure 2.** *Mean scores of pretest, end-of-module test and delayed test according to question level (basic knowledge and clinical correlation) and their corresponding KLP values*

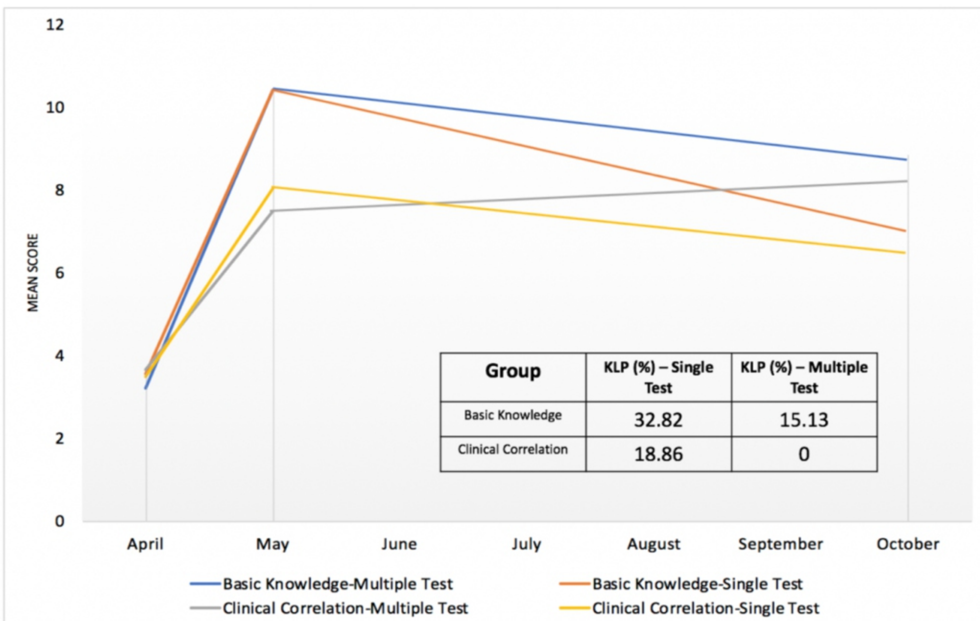


**Figure 3.** *Comparison of overall mean scores for multiple and single testing group on pretest, end-of-module, and final assessment according to question level (basic knowledge and clinical correlation)*

difference; (*p=0.261*). A. significant difference in mean scores exist between clinical correlation-multiple testing and basic knowledge-single testing; (*p<.001*).

## Discussion

*Overall score*

In this study, knowledge retention and loss were investigated among 1st year students by retesting them five months after using the same test items given during the diagnostic pretest and summative (end-of-module) assessment. The result showed that there was a low baseline knowledge among the participants during the diagnostic assessment (Figures 3 and 4). In turn, the scores significantly increase when tested after going through an instructional module. After taking the test-retest five months after the administration of the summative assessment, a significant knowledge loss (p<0.001; KLP=15.65%) in the overall score was observed within five months of retention interval (RI). By assumption, there is approximately 3.13% knowledge loss occurrence per

**Table 4.** *Paired and independent t-test comparison of total mean scores of pretest, end-of-module and final delayed tests according administration of multiple testing and single testing, and question level (basic knowledge and clinical correlation)*

| | Pairs | Mean Score | N | t | Sig |
|---|---|---|---|---|---|
| Paired T-test | Basic knowledge-multiple testing (pretest)<br>Basic knowledge-multiple testing (end-of module) | 3.21<br>10.44 | 113 | -28.165 | 0.000 |
| | Basic knowledge-multiple testing (end-of-module)<br>Basic knowledge-multiple testing (final delayed test) | 10.44<br>8.86 | 113 | 5.796 | 0.000 |
| | Basic knowledge-single testing (pretest)<br>Basic knowledge-single testing (end-of module) | 3.57<br>10.42 | 112 | -23.060 | 0.000 |
| | Basic knowledge-single testing(end-of-module)<br>Basic knowledge-single testing (final delayed test) | 10.42<br>7.00 | 112 | 11.306 | 0.000 |
| | Clinical correlation-multiple testing (pretest)<br>Clinical correlation-multiple testing (end-of module) | 3.66<br>7.50 | 112 | -14.129 | 0.000 |
| | Clinical correlation- multiple testing (end-of-module)<br>Clinical correlation- multiple testing (final delayed test) | 7.50<br>8.31 | 112 | -2.883 | 0.005 |
| | Clinical correlation-single testing (pretest)<br>Clinical correlation- single testing (end-of module) | 3.5<br>8.06 | 112 | -17.056 | 0.000 |
| | Clinical correlation-single testing(end-of-module)<br>Clinical correlation-single testing (final delayed test) | 8.06<br>6.54 | 112 | 5.175 | 0.000 |
| Independent T-test | Basic knowledge-multiple testing (pretest)<br>Basic knowledge-single testing (pretest) | 3.21<br>3.57 | 113<br>112 | -1.326 | 0.186 |
| | Basic knowledge-multiple testing (end-of module)<br>Basic knowledge-single testing(end-of-module) | 10.44<br>10.42 | 113<br>112 | 0.062 | 0.951 |
| | Basic knowledge-multiple testing (final progress)<br>Basic knowledge-single testing (final delayed test) | 8.86<br>7.00 | 113<br>112 | 4.346 | 0.000 |
| | Clinical correlation-multiple testing (pretest)<br>Clinical correlation-single testing (pretest) | 3.66<br>3.50 | 113<br>112 | 0.546 | 0.573 |
| | Clinical correlation-multiple testing (end-of module)<br>Clinical correlation-single testing(end-of-module) | 7.50<br>8.06 | 113<br>112 | -1.437 | 0.152 |
| | Clinical correlation-multiple testing (final delayed test)<br>Clinical correlation-single testing (final delayed test) | 8.31<br>6.54 | 113<br>112 | 4.781 | 0.000 |
| | Clinical correlation-multiple testing (final delayed test)<br>Basic knowledge-single testing (final delayed test) | 8.31 | 113 | 3.238 | 0.001 |

month. If knowledge loss continuously declines in one year, this is going to be equivalent to 37.56%. This finding confirms the result of the meta-analysis study, which states that a two-third to three-fourth retention after one year [2] and 50% after 8-10 months [5]. If RI is uninterrupted (no intervention), it is estimated that around 2-3 years, none of the acquired knowledge at the end of instruction can be remembered. From Bahrick's [8] several naturalistic studies on retention, he was able to observe a triphasic behavior of knowledge retention. The first phase (first six years) presents an exponential decline from the acquired knowledge gained after instruction. The second phase (6-30 years) also called **"permastore,"** a phenomenon in which there was an observed permanent retrieval of acquired knowledge. A possible reason is that during the initial storage of knowledge, there was a repeated relearning or rehearsal that happened during banking. Repeated learning is a common practice among medical students such that they tend to study in multiple frequencies for high stake examinations since these assessments are graded and reflected in their overall academic performance. The last phase is a period of knowledge loss, which is due to the natural course of aging.

The low baseline score (Figures 2 and 3) can be attributed to the fact that most of the participants have retained knowledge which they earned from their undergraduate or pre-medicine science courses, or probably, some students have managed to do an early pre-reading on the topics; thus, the score is not an absolute zero. Also, the possibility of guessing the correct answer for multiple-choice items can be a factor for the low pretest scores. As observed, overall scores increase after the instructional exposure. The increase in the score of the summative assessment can be attributed to the fact that the exam is a scheduled one (incorporated in the academic schedule) such that the students have allotted time and effort to study and prepare for the examination, and the exam score makes a significant component of the student's academic performance or grade.

Knowledge retention is determined by two factors: first, the amount of knowledge at the end of exposure, and second, the length of RI. The amount of knowledge post-exposure is directly proportional to the level of retention, while the length of RI is inversely proportional to retention. Rehearsal and reinforcement during the period of RI delay the downhill trend of knowledge decay, which can be done by revisiting the learned materials [2]. Probably, the students who participated in the study may not have revisited the module or re-exposed themselves to the same material. In the first two months of the RI, this coincides with the academic break, and most of the students spend most of their time with the family or vacation. It presumed that almost everyone during this period did not review any of their previous course materials. During the next three months of RI, as they venture to the new academic curriculum, they are much focused on the new material rather than revisiting the concepts learned when they were in the first year. Another possible reason is probably due to how the curriculum was designed in the second level, such that none of the neurology topics or instructions has been part of the first few modules in the first quarter of the academic year. Lack of activities that will promote retrieval of learned neurology concepts resulted in further decline in the overall score.

*Question level*

This study also investigated knowledge retention comparing basic knowledge versus clinical correlation questions (Figure 2). Half of the written questions of the tool asks for basic concepts, and the other half focus on clinical correlation concepts. The result of the study showed a non-significant difference for both question-level as far as diagnostic assessment is concerned. Advanced reading, stock knowledge and "guessing chance" allows them to answer some items in the diagnostic assessment. Basic knowledge scores were significantly higher as compared with clinical correlation post-instruction due to the fact that the course itself is reach in basic science concepts.

As described by Klement *et al.* [9], clinical correlation are tools that aid students in associating basic science concepts with medical applications, and its use can be translated to improved grades and retention. The finding of Klement [9] and Lazic [4] compliments the result of this study in the sense that clinical correlation retention is better than basic knowledge. It is based on the decreasing trend on the scores of basic knowledge as compared with clinical correlation items. Though the basic knowledge score is higher compared with clinical correlation scores, it can be observed that the more downhill slope and a high KLP (23.97%) of the basic knowledge which signifies more loss as compared with clinical correlation.

Basic knowledge items scored higher than the clinical correlation for both summative and delayed tests simply because the material, (*i.e.*, neuroanatomy), is mainly rich in basic concepts. Another explanation to this is that first-year medical students have a poor grasp of clinical correlation because their concept of the whole clinical picture is still low. However, the greater knowledge decline with the basic knowledge group can be attributed to the fact that students in the 2nd level are overwhelmed with the new advanced basic concept (in Pathology, Microbiology, and Pharmacology); hence, they are gradually forgotten. Also, none in the instructional materials and assessment tools (within the RI period) in the 2nd level covers the neuroanatomy topics. This decline probably translates to knowledge undergoing into the "state of latency", maintaining the recognizability of the stored material rather than going into the process of decay (knowledge lost forever). Knowledge latency maintains the familiarity of the stored material in the memory bank allowing the student to recognize the learned concept once re-exposed to the same idea, thus reinforcing retention.

In the study of Klement *et al.* [9] on the effectiveness of clinical correlation in the retention of knowledge, they associate the usage of cases or clinical scenarios allowing students to put different pieces of knowledge together in a real-life perspective. In the information processing theory, this association cement the learned knowledge in short-term memory, thereby improving retention. Though clinical correlation items were scoring low as compared with the basic concepts, the retention is long-term. Anatomical concepts that are taught by connecting the idea to its clinical relevance are much appreciated by students, thus firmly encoded in the memory bank.

On the delayed testing result, clinical correlation concepts lead the rank translated to have better retention as compared with basic knowledge.

*Effect of Multiple and Single Testing Intervention*

In the analysis of delayed testing intervention, the KLP for the intervention group (multiple testing) and the non-intervention group (single testing) are compared. In the overall score (Figure 3), the result showed a comparative higher KLP value for the multiple testing group (4.34%) vs. the single testing group (26.73%), which translates to a pronounced knowledge loss among students who just took a single exam five months after instructional exposure. The result showed a 4-5x increase in knowledge retention among those administered with multiple tests.

The result of this study confirms the testing effect theory and the study by Larsen [7], Butler [10] and Roediger [11] that repeated testing enhances memory retention of the learned knowledge. The testing effect helps to improve retention, employing repeated exposure to the material, and facilitation of retrieval practice [7,10,11].

When the students were given the individual test components of the serial testing intervention, the "state of latency" of the concepts are believed to reach the sense of recognition and was able to resurface. This process may be vital in improving retention later. Furthermore, the test itself became the medium such that its representativeness with the test blueprint also enhances learned topics that they gain at the end of instruction. The test itself is also regarded as a teaching-learning strategy, though, some data manifested an increase in the trend of knowledge retention and can be regarded as knowledge gain. However, during the application of the statistical treatment, these increases were noted to be non-significant. The ability of repeated testing to increase knowledge even without a formal teaching-learning intervention can be explored in future studies.

## Conclusion

Significant knowledge, (*i.e.*, drop or "loss"), whether basic or clinical, occurs after knowledge is gained post-instruction. However, greater knowledge loss is more pronounced among basic concepts. Clinical correlation was noted to have the highest retention capacity. Repeated testing demonstrates a higher retention (KLP=4.34%) compared to those administered with a single test only (KLP=26.73%). As observed, knowledge level significantly had higher knowledge retention when administered with multiple tests (KLP range = 0-16.83%) versus a single test only (KLP=4.21-39.92%). To reduce the effect of knowledge loss among basic concepts, this study recommends that multiple testing strategies be employed.

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