**University of Toronto**

# Quercus Data Analysis for the Course PHM305

*Assessing the Relationship Between Student Performance on a Pre-Quiz, Post-Quiz and Simulation*

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**Course:** PHM305H1: Medication Therapy Management 4

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**Background and Objective**

Medication Therapy Management 4 (MTM4), also known as PHM305, is the final course in a four-part course series that is delivered longitudinally over three years of the pharmacy undergraduate program. MTM4 builds on the skills developed in previous MTM courses, offering students opportunities to apply and integrate materials learned through many courses in the curriculum to date. This course focuses on developing and enhancing skills needed to optimize the pharmacist's scope of practice in providing effective patient care in Ontario. Lectures and simulations emphasize the pharmacist's roles as a communicator, care provider, scholar, professional, manager, collaborator, and advocate, to prepare students for their Advanced Pharmacy Practice Experience (APPE) rotations.

A key component of this course is teaching and assessing a student's ability to renew and adapt prescriptions. This complex task requires knowledge of pharmacology, diseases, medication management, pharmacokinetics, drug interactions, patient preference, Ontario legislation, and professional judgment. These skills are assessed in a simulation context with a standardized patient. Historically students who have worked in a community pharmacy do quite well on these simulations, while those with no experience tend to struggle. However, it is not clear whether the struggling students are having difficulty with the legislation, general pharmacy knowledge, or integration of this knowledge. In this context, research on pre-testing shows that students who perform poorly on a pre-test may benefit more from subsequent instruction.

Thus, the objective of this project was to evaluate the relationship between students' performance on a Pre-Quiz and their performance on a Post-Quiz and final simulation. These could be used in future iterations of the course to create an adaptive learning module, where students who perform poorly initially can be directed towards more resources to support them in their learning before attempting a high-stakes simulation.

**Methods**

Reports on the Pre-Quiz, Post-Quiz and Final Simulation (i.e., Lab 3) were extracted from the course's page on the Learning Management System. Given that each assignment had a different number of total questions, the percentage score was used as the primary metric of student performance.

Students were included in the final analysis only if they completed all three assignments. Thus, students with missing submissions or students who submitted an empty assignment were excluded from the analysis.

The descriptive statistics for the percentage scores were expressed in terms of mean and standard deviation, median and interquartile range (i.e. 25th and 75th percentiles), and minimum and maximum values. The paired comparison of the scores between the three assignments was performed by the Friedman Test followed by the Holm-Bonferroni method. A grouped analysis according to the performance in the Pre-Quiz was also carried out. A P-value smaller than 0.05 was considered statistically significant for all cases.

**Main Findings**

*Part 1: Descriptive Statistics*

**Table 1** shows the descriptive statistics of the percentage scores for the Pre-Quiz, Post-Quiz and Lab 3. In total, 208 students completed all three assignments and were included in the analyses. The Pre-Quiz had the

lowest median score (median (IQR) = 66.7% (50% − 83.3%)), while the Post-Quiz showed the highest student performance from all assignments (median (IQR) = 88.9% (77.8% − 100%)). The median score from Lab 3 (median (IQR) = 70% (63% − 77%)) was comparable to the one from the Pre-Quiz.

These changes in scores are also illustrated by the deltas (i.e., differences) between the assignments **(Table 1)**. The largest positive delta (i.e., increase in student performance between assignments) was found for the differences between Post-Quiz and Pre-Quiz scores (median (IQR) = 16.6% (5.6% − 33.3%)), while the largest negative delta (i.e., decrease in performance between assignments) was between Lab 3 and Post-Quiz scores (median (IQR) = -19% (-27% − -8.7%)).

**Table 1:** Descriptive statistics of the percentage scores for the Pre-Quiz, Post-Quiz and Lab 3 and the deltas (i.e., differences) between scores.

|  | N | AM ± SD | Median (IQR) | Min-Max |
|---|---|---|---|---|
| **Pre-Quiz** | 208 | 66.9 ± 19.7 | 66.7 (50 − 83.3) | 16.7 - 100 |
| **Post-Quiz** | 208 | 85.5 ± 13.9 | 88.9 (77.8 − 100) | 22.2 − 100 |
| **Lab 3** | 208 | 69.2 ± 9.7 | 70 (63 − 77) | 42 - 93 |
| **Δ Post - Pre** | 208 | 19.6 ± 22.7 | 16.7 (5.6 − 33.3) | -44.5 − 83.3 |
| **Δ Lab 3 - Pre** | 208 | 2.2 ± 21.1 | -0.5 (-14.3 − 16) | -41.3 − 59.7 |
| **Δ Lab 3 - Post** | 208 | -17.4 ± 16 | -19 (-27 − -8.7) | -49 − 48.6 |

N: Number of students; AM: Arithmetic mean; SD: Standard deviation; IQR: Interquartile range; Min-Max: Minimum and maximum values; Δ: Delta (Difference) between two quiz scores.

**Figure 1** presents the histograms with the distributions of the scores for each assignment and delta. The Pre-Quiz and the Post-Quiz had a left-skewed score distribution. This distribution is particularly notable for the Post-Quiz where a score of 100% was the most frequent mark.
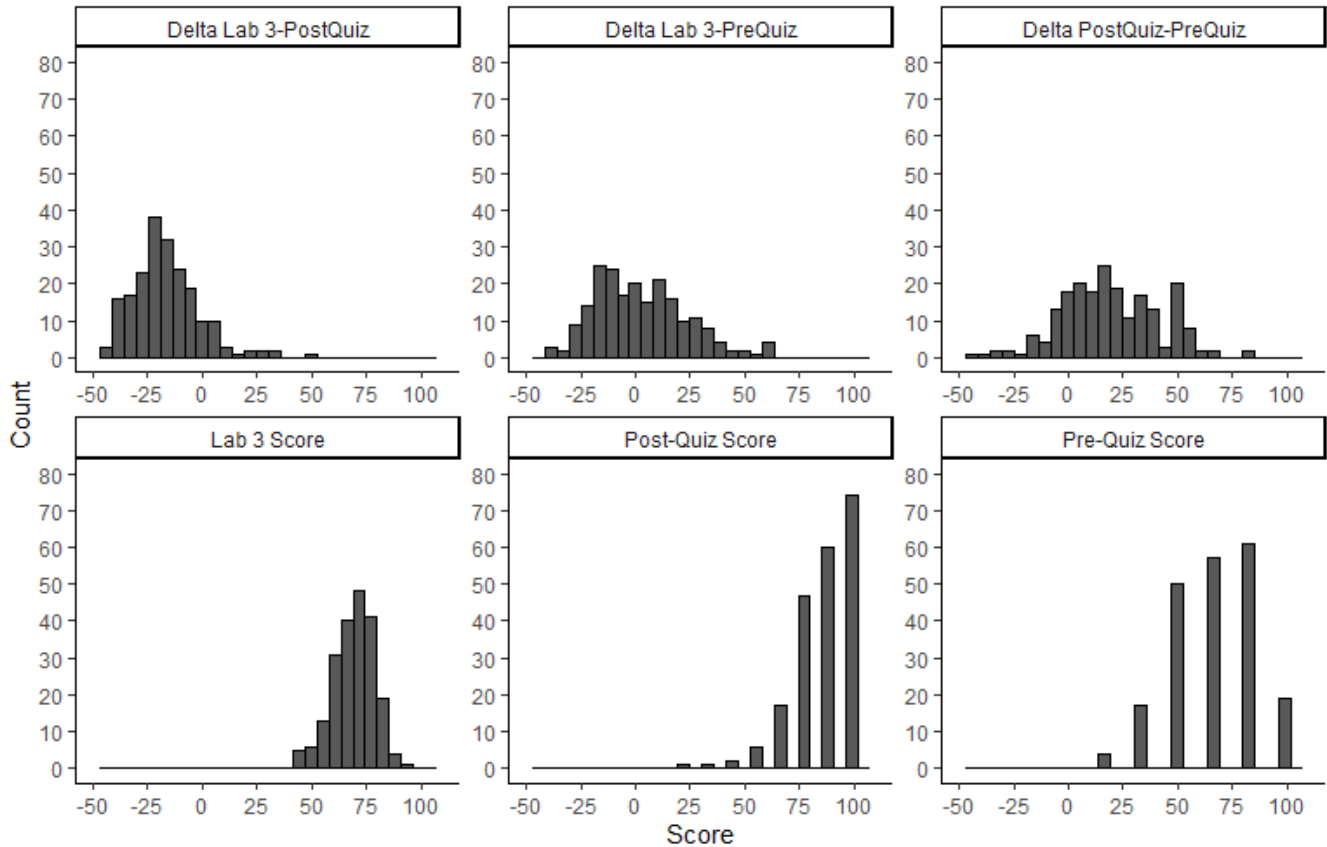
**Figure 1:** Histograms for the Score Distributions.

*Part 2: Comparison Between Pre-Quiz, Post-Quiz and Lab 3 Scores.*

**Figure 2** presents the violin plots showing the paired comparison of students' scores between the three assignments. There was a statistical increase in scores from the Post-Quiz compared to the Pre-Quiz ($P < 0.001$). In addition, Post-Quiz scores were statistically higher than the Lab 3 scores ($P < 0.001$). Thus, when considering the sequence of the assignments in the course, the overall student performance increased from the Post-Quiz to the Pre-Quiz but decreased for Lab 3. There was no statistical difference between the scores from the Pre-Quiz and Lab 3 ($P = 0.24$).
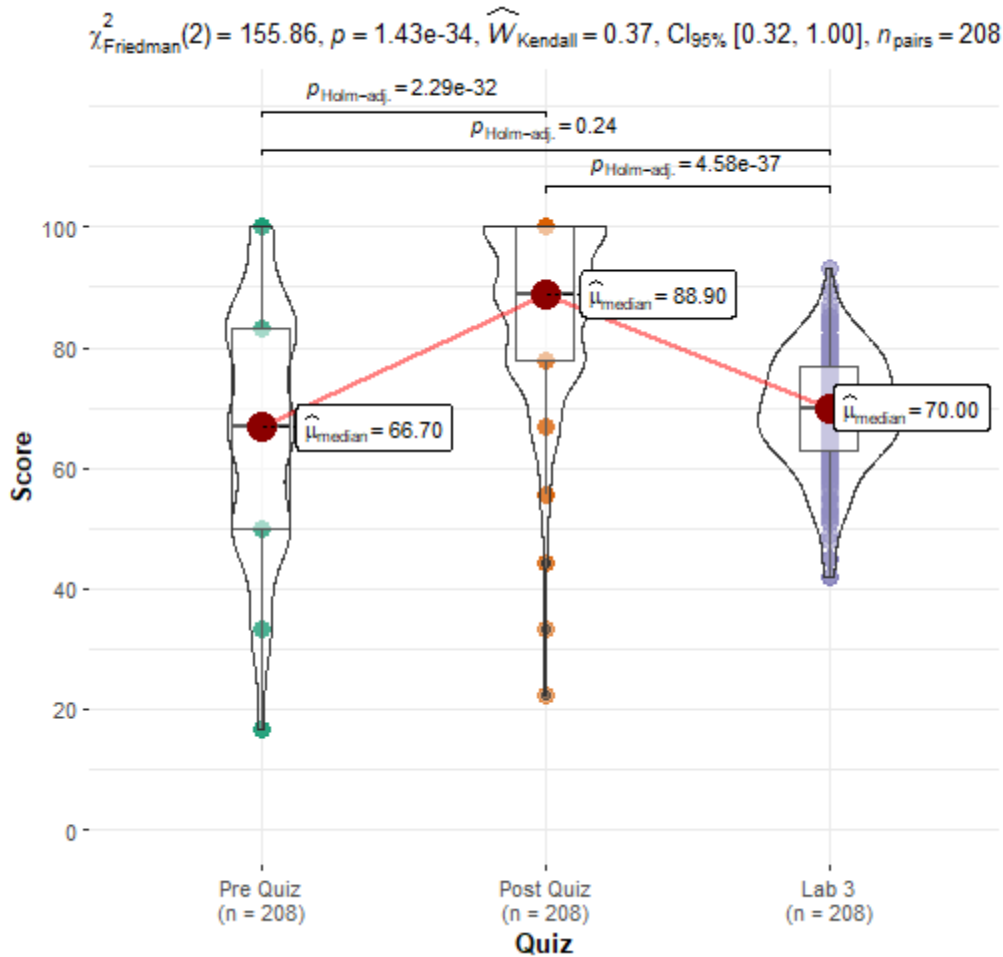
$$\chi^2_{Friedman}(2) = 155.86, \, p = 1.43e\text{-}34, \, \widehat{W}_{Kendall} = 0.37, \, CI_{95\%} \, [0.32, 1.00], \, n_{pairs} = 208$$

$p_{Holm\text{-}adj.} = 2.29e\text{-}32$

$p_{Holm\text{-}adj.} = 0.24$

$p_{Holm\text{-}adj.} = 4.58e\text{-}37$

$\widehat{\mu}_{median} = 88.90$

$\widehat{\mu}_{median} = 66.70$

$\widehat{\mu}_{median} = 70.00$

Pre Quiz (n = 208)    Post Quiz (n = 208)    Lab 3 (n = 208)

**Quiz**

Score

**Figure 2:** Violin Plots with Comparisons of the Scores by Quiz.

*Part 3: Student Performance by Quiz According to the Pre-Quiz Score Category.*

Next, student performance was compared between quizzes according to their score category on the Pre-Quiz. This grouping was based on the distribution quartiles of the Pre-Quiz score, as shown in Table 1. In this context, the four groups were defined as **Pre-Quiz Score < 2** (i.e., percentage score < 50%), **Pre-Quiz Score = 3** (i.e., percentage score ≥ 50% and < 66.7%), **Pre-Quiz Score = 4** (i.e., percentage score 66.7% and < 83.3%), and **Pre-Quiz Score = 5 or 6** (i.e., percentage score ≥ 83.3%). *(Note: The Pre-Quiz had a total of six questions).*

The descriptive statistics of the scores of Post-Quiz and Lab 3 by Pre-Quiz categories, as well as the visual representation and statistical comparison of these results, are presented in **Table 2** and **Figure 3**, respectively. As shown in **Figure 3**, all four groups had the same Post-Quiz median score of 88.9%. This indicates that all students achieved a comparable overall score in the Post-Quiz independently of their performance in the Pre-Quiz. The increase in score from the Pre-Quiz to the Post-Quiz was statistically significant for all groups (P < 0.001), except for the students who had a Pre-Quiz Score = 5 or 6.

There was a statistically significant decrease in students' performance in Lab 3 compared to the Post-Quiz for all groups (P < 0.001). This decrease in students' performance, however, does not seem to be dependent on

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the Pre-Quiz category since the median Lab 3 score for all groups was comparable. On the contrary, students with the worst performance in the Pre-Quiz (i.e., Pre-Quiz Score < 2 or = 3) were the ones that had a statistically significant increase in score in Lab 3, thus benefiting the most from the Pre-Quiz.

**Table 2:** Descriptive statistics of Post-Quiz and Lab 3 scores by Pre-Quiz score categories

| | N | AM ± SD | Median (IQR) | Min-Max |
|---|---|---|---|---|
| *Post-Quiz Percentage Scores by Pre-Quiz Categories* | | | | |
| **Pre-Quiz Score < 2** | 21 | 82.5 ± 14.7 | 88.9 (77.8 – 88.9) | 44.4 - 100 |
| **Pre-Quiz Score = 3** | 50 | 87.8 ± 12.7 | 88.9 (77.8 – 100) | 55.6 – 100 |
| **Pre-Quiz Score = 4** | 57 | 84.2 ± 15.4 | 88.9 (77.8 – 100) | 22.2 – 100 |
| **Pre-Quiz Score = 5 or 6** | 80 | 88.5 ± 13.1 | 88.9 (77.8 – 100) | 44.4 – 100 |
| | | | | |
| *Lab 3 Percentage Scores by Pre-Quiz Categories* | | | | |
| **Pre-Quiz Score < 2** | 21 | 71.3 ± 9.9 | 70 (66 – 76) | 52 – 93 |
| **Pre-Quiz Score = 3** | 50 | 68.1 ± 9.2 | 67 (61.2 – 76.2) | 49 – 89 |
| **Pre-Quiz Score = 4** | 57 | 66.5 ± 10.8 | 67 (61 – 75) | 42 – 86 |
| **Pre-Quiz Score = 5 or 6** | 80 | 71.2 ± 8.6 | 71.5 (65.7 – 78) | 42 – 87 |

N: Number of students; AM: Arithmetic mean; SD: Standard deviation; IQR: Interquartile range; Min-Max: Minimum and maximum values.
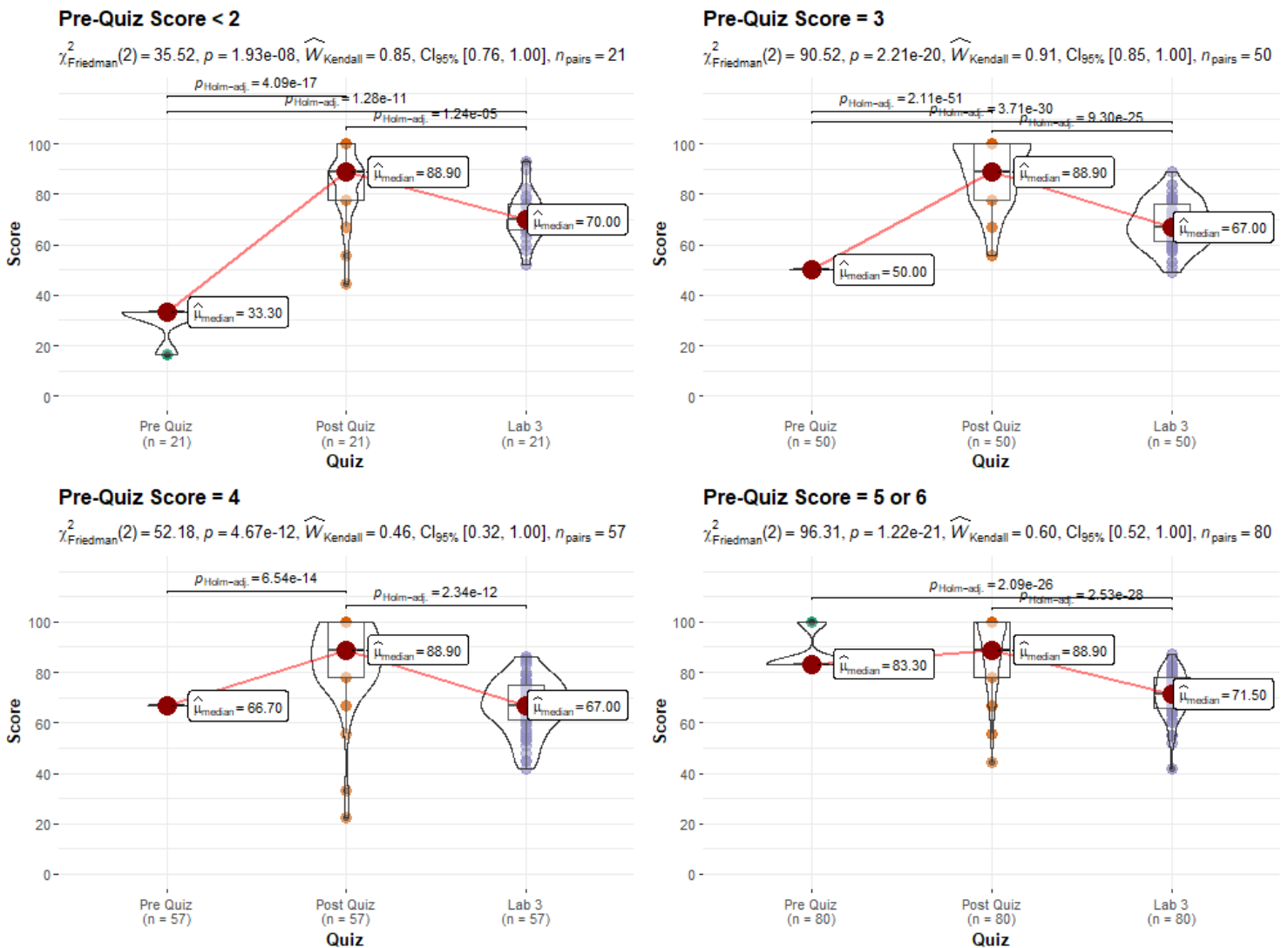
**Figure3:** Violin Plots with Comparisons of the Scores by Quiz and According to the Pre-Quiz Score Categories.

Finally, **Figure 4** shows the distribution of Lab 3 HPF (i.e., Honours, Pass, Fail) grades according to the Pre-Quiz categories. Students who had the highest (i.e., 5 or 6) or the lowest (i.e., < 2) scores in the Pre-Quiz were the ones with the lowest failure percentage in Lab 3 (10% and 14.3% failure, respectively). On the other hand, students with an average performance in the Pre-Quiz (i.e., a score of 3 or 4) had the highest failure percentages in Lab 3 (20% and 24.6% failure, respectively). Interestingly, the only three students that had an Honours score in Lab 3 were in the lowest Pre-Quiz categories.
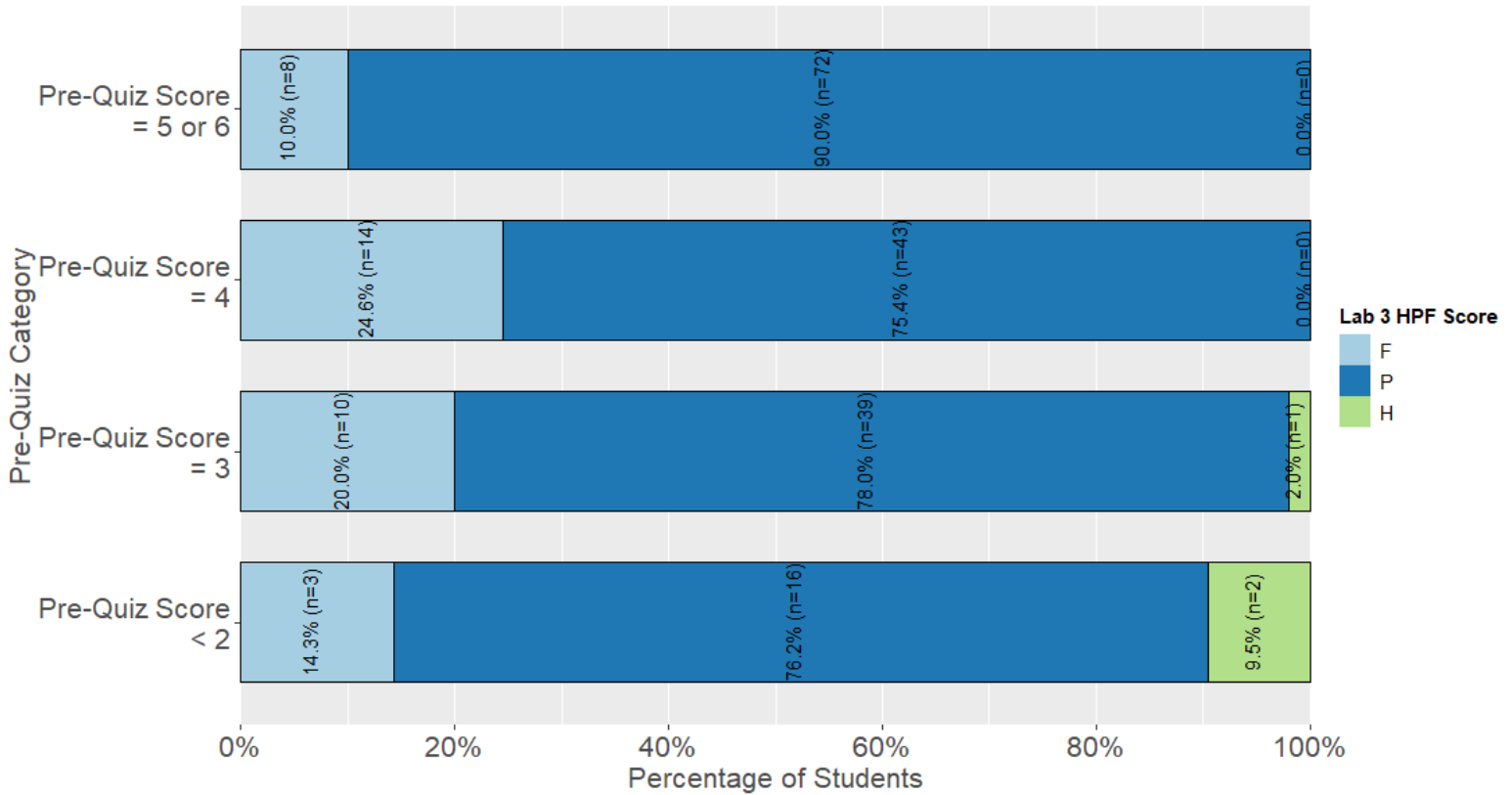
**Figure 4:** Distribution of Lab 3 HPF (Honours, Pass, Fail) Grades According to the Pre-Quiz Categories.

**Conclusions and Recommendations**

There was a significant increase in the general score from the Pre-Quiz to the Post-Quiz. In addition, students achieved a general similar grade in the Post-Quiz regardless of their performance on the Pre-Quiz. This suggests that the Pre-Quiz succeeded in levelling the students' knowledge for the Post-Quiz.

Although the general performance in Lab 3 decreased compared to the Post-Quiz, these lower scores were generalized and were not associated with the performance in the Pre-Quiz. On the contrary, students with the lowest scores in the Pre-Quiz were the ones that saw the greatest improvements in both the Post-Test and Lab 3.

A recommendation for future studies is to apply a questionnaire at the beginning of the course term to access prior knowledge/work experience related to the course's content. Although the Pre-Quiz scores can be used as a proxy for prior knowledge, future analyses would benefit from this direct categorization. In addition, future investigations could explore the potential reasons for the increase in the performance of students in the lowest Pre-Quiz categories. This could be achieved by assessing the associations between student activity/engagement in the different groups with the performance in the Post-Quiz and Simulation.