



SPORTS, ACADEMICS AND THE TOWER OF HANOI PROBLEM

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Abstract: The Tower of Hanoi (TOH) is a well-known combinatorial puzzle first posed by the French mathematician Édouard Lucas in 1883. Originally studied in its three-peg formulation, the TOH has become a widely used instrument for detecting and diagnosing cognitive and psychological impairments. Increasingly, researchers have found new and improved ways to apply it across various fields of study. In this paper, we study the correlation between a student's academic background, participation in sports and extracurricular activities, and the time taken to solve the Tower of Hanoi puzzle.

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Keywords - Tower of Hanoi, extracurricular activities, academics, cognitive assessment, problem-solving.

I. INTRODUCTION

The Tower of Hanoi problem was proposed over a hundred years ago by Lucas. In this puzzle, a player is given three pegs and a certain number r of rings of distinct sizes. All rings are initially stacked on the first peg (the source), ordered by size with the smallest at the top and the largest at the bottom. The goal is to transfer the entire tower to the third peg (the destination) while observing the following rules:

1. At each step, only one ring may be moved.
2. The moved ring must be the topmost ring on its peg.
3. At no point may a ring be placed on top of a smaller ring.

The well-known recursive algorithm that accomplishes this task requires $2^r - 1$ moves and has been shown to be the unique optimal algorithm for the three-peg Tower of Hanoi problem (see [4]).

A natural generalization of the problem involves increasing the number of pegs. This seemingly simple change renders the problem non-trivial: the optimality of the solution has not yet been proved for $p \geq 5$ pegs, making it an important open problem in combinatorics (see [4]).

The TOH is widely used in the field of psychology to assess patients on the basis of their neurological functioning, particularly with regard to problem-solving capabilities and cognitive performance. It has also found applications in backup rotation schemes (see [1], [2], [3]).

In a less conventional application, the puzzle's sequencing rules can serve as a basis for optimizing production-line operations in industrial settings.

This study was conducted as part of the Avishkar Research Convention, a premier research-oriented competition in Maharashtra, India.

For our study, a group of 100 students was taken and their performance on the puzzle with 3 rings and 3 pegs was observed. Information was collected from the students regarding various aspects of their academic, co-curricular, and extracurricular activities. Students were also asked about their stress levels.

In this study, we investigate the correlation between the time taken to solve the puzzle and (a) the academic discipline studied by the student, and (b) their participation in extracurricular activities.

II. AIM

To determine whether a student's academic background, participation in sports, and involvement in other extracurricular activities affect the time and number of moves required to solve the Tower of Hanoi puzzle.

III. METHODOLOGY

We conducted a survey on a sample of 100 students from different academic backgrounds and asked them to solve the three-ring, three-peg Tower of Hanoi puzzle. Data was collected using a Google Form to record each student's personal and academic information as well as their performance on the puzzle.

IV. WHAT WE EXPECTED

We expected to find a meaningful relationship between students' academic backgrounds, their extracurricular involvement, and their overall puzzle performance.

Students who do not typically face difficulty in solving puzzles tend to possess stronger logical and sequential reasoning abilities. Moreover, a composed and strategically minded athlete is likely to approach the puzzle methodically and arrive at a solution efficiently. For potential industrial applications, we aimed to evaluate the practicality and efficiency of applying the puzzle's sequencing logic to real-world processes.

V. OBSERVATIONS

Figure 1 shows the distribution of the 100 surveyed students across academic disciplines, further categorized by extracurricular activity (ECA) participation. Engineering students with ECA participation form the largest group, comprising roughly 30-35% of the sample, followed by Commerce and Commerce-ECA students at approximately 15-20% combined, and Mathematics with Mathematics-ECA at around 10-12%. The remaining streams, Arts, Geology, and Zoology, with and without ECA each contribute a smaller share, ranging from 2-8%. This distribution indicates that the sample is weighted toward technical disciplines, particularly Engineering, which should be considered when interpreting group-level comparisons in puzzle performance.

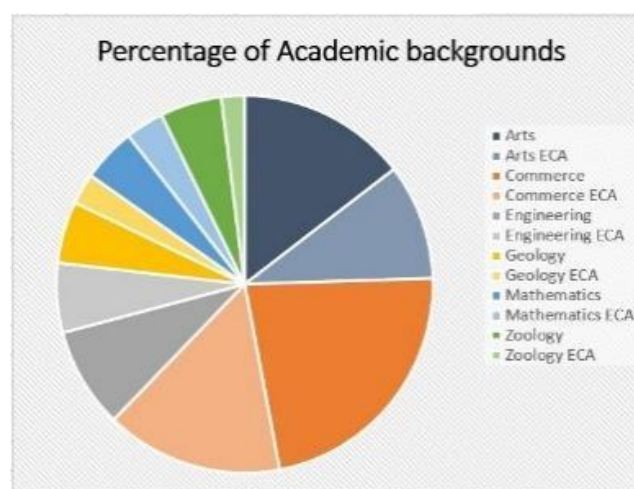


fig. 1: distribution of surveyed students by academic stream and ECA participation (n = 100).

Figure 2 displays Pearson correlation coefficients across 15 collected variables. The strongest off-diagonal correlations appear between Solve Time and Moves (approximately 0.4-0.6), which is expected since additional moves naturally increase solving time, and between Stream and Subject Specialization (approximately 0.6-0.8), as these capture related academic information. Age and Year also correlate moderately (approximately 0.4-0.6). Notably, Solve Time shows very weak linear correlations with most individual variables such as SGPA, Stress Level, Hours Slept Daily, and Books Read, all near zero. ECA and Sports Played likewise show only faint associations with Solve Time (roughly -0.1 to -0.2). This suggests that no single variable in isolation is a strong linear predictor of puzzle-solving speed; rather, the advantage observed in the percentile analysis likely arises from a combination of factors acting together, pointing toward the need for multivariate analysis in future work.

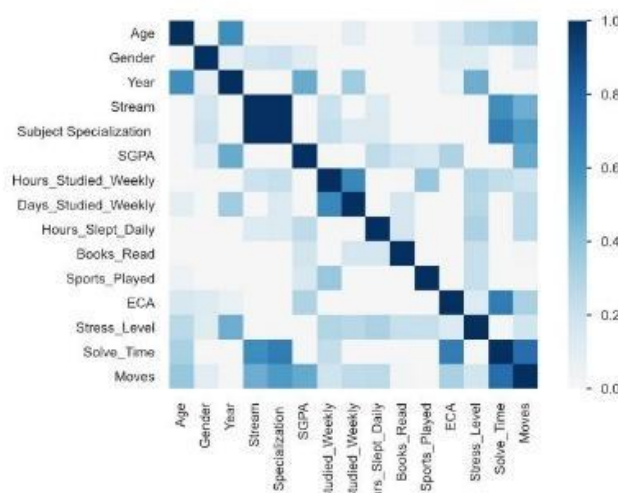


fig. 2: heatmap of Pearson correlation coefficients across 15 collected variables.

Figure 3 shows a density histogram with a kernel density estimation (KDE) curve showing the distribution of solve times across all 100 students. The distribution is approximately normal and centred around 90-110 seconds, with a peak density of roughly 0.0175. Most students solved the puzzle within 60 to 150 seconds. The distribution exhibits a slight right skew, with a longer tail extending toward 180-200 seconds and a small secondary bump near 170-180 seconds. This right tail likely corresponds to students who found the puzzle more challenging, consistent with the observation that students from non-quantitative backgrounds without extracurricular participation tended to take longer, while the central clustering confirms that the three-ring, three-peg puzzle presents a moderate and fairly uniform challenge for the majority of participants.

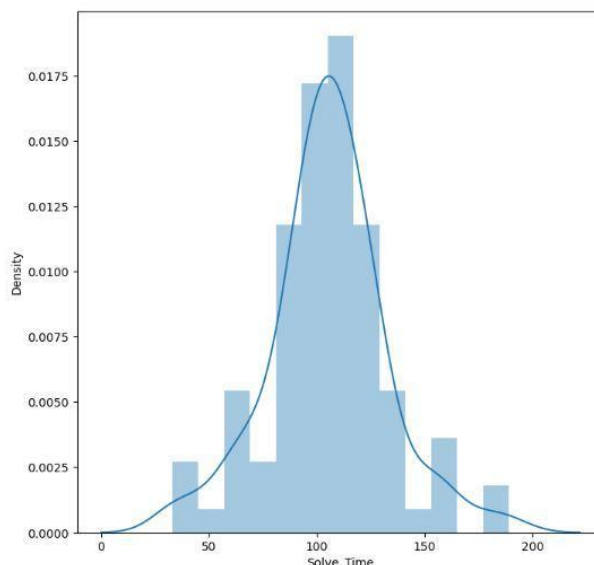


fig. 3: density histogram with KDE curve showing the distribution of solve times (n = 100).

The following observations are noted from the data:

- The 25th percentile (top 25%) is heavily dominated by students from Engineering and Mathematics backgrounds who have participated in both extracurricular activities and sports.
- The 75th percentile is dominated by students from non-technical backgrounds such as Zoology and Arts, none of whom had extracurricular participation.
- Two students from the Arts background who had participated in extracurricular activities performed below the mean solve time, suggesting that ECA engagement may partially compensate for a non-quantitative academic background.
- The time taken to solve the puzzle shows dependence on both the subject studied by the student and their extracurricular participation.

VI. CONCLUSION

Consistent with our initial expectations, students who pursued more quantitative or cognate subjects and participated in some form of extracurricular activity performed substantially better on the puzzle. These results provide preliminary evidence supporting the potential use of the Tower of Hanoi as a tool for assessing aspects of a student's cognitive readiness and academic orientation, and they motivate further research into how this puzzle can be applied in educational assessment contexts.

VII. SCOPE FOR FURTHER RESEARCH

Several variations of the Tower of Hanoi problem have been studied (see [5]). Similar experiments can be conducted using puzzles with more pegs or rings, and corresponding observations can be made. Additionally, the puzzle can be used as a training tool for developing logical and recursive thinking skills. Future studies should also consider employing larger, more balanced samples and multivariate statistical methods to more precisely identify the factors influencing puzzle performance.

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