AN INTEGRATED OPTIMIZATION AND RESOURCE AVAILABILITY FRAMEWORK FOR HIGHER EDUCATION TIMETABLING AND CAPACITY PLANNING.

Banuka Kularatne[1]*& Ravindi Jayasundara[2]

[1]Independent Researcher, Sri Lanka
[2]Department of Mathematics, University of Moratuwa, Sri Lanka.

*Corresponding author – Email: banukadimuthu@gmail.com

Abstract

Efficient academic timetabling is essential for reliable teaching, workload control, and institutional expansion. This study develops an integrated optimisation and resource availability framework for a Sri Lankan higher education institution. Its principal contribution is linking allocation to fixed teaching slots with infeasibility diagnostics and a multidimensional assessment of remaining workloads and resource availability for expansion planning. Two binary integer programming models, implemented in Julia using JuMP and HiGHS, allocate 68 weekly sessions and using 13 lecturers, five classrooms, and four computer laboratories. The facility objective minimises a weighted sum of computer laboratory use for non-laboratory sessions, facilities used, and unused seats. The lecturer objective minimises the number of lecturers assigned. Constraints enforce specialisation, daily availability, programme requirements, a 20 hour weekly workload limit, seating capacities, laboratory requirements, non-overlapping assignments. Total Julia execution took 16.2 seconds. The researcher estimated 2–3 hours for complete manual allocation and calculations. All 68 sessions, representing 196 teaching hours, were allocated without resource conflicts. All 27 laboratory designated sessions received laboratories, with no other sessions occupying them. A constructed manual method using best utilization of resources and lecturer assignment fully allocated 65 sessions (95.6%), compared with 68 (100%) under the optimisation model. Lecturer workload utilisation was 75.4% of the aggregate weekly limit, leaving 64 calculated spare capacity teaching hours. Availability and workload screening retained 42 of 78 candidate programme daytime blocks and generated 34 indicative allocations, visualised through Sankey and hierarchical diagrams. These recommendations require joint workload, overlap, and batch-size validation before implementation. The framework can support reliable teaching, protect lecturers from excessive workloads, and guide transparent allocation across programmes, providing a basis for reducing resource waste and planning more equitable access to educational facilities. Weekly utilization analysis classified lecturers, facilities as utilized, underutilized, or idle and quantified their remaining capacity for future teaching activities.

Keywords: Academic timetabling, Integer programming, Resource allocation, Capacity planning, Higher education