

What Really Happens in the Hallways

A Multidisciplinary Analysis of Pedestrian Flows in a New Secondary School Building

Bram Leisink & Myrthe Sas, Mondial College, Nijmegen, The Netherlands



INTRODUCTION

When Mondial College Leuvenbroek moves into its new building, the approximately 1,200 students will need to navigate the corridors within a three-minute lesson-change window at each class change. The question of where congestion will form is hard to answer after the fact – by then, the architecture is fixed. This study addresses it before the building opens, through a *pre-occupancy* analysis that predicts pedestrian flow entirely from architectural drawings and empirical behavioral data.

The work develops a multiscale framework: from controlled behavioral experiments, through graph-theoretic network simulation and combinatorial optimization, to agent-based microscopic crowd modeling. Each layer addresses what the previous one cannot, and the overall methodology is independent of the specific building studied.

BEHAVIORAL CHARACTERIZATION

Standard pedestrian models assume homogeneous agents with well-defined desired speeds. Adolescent school populations deviate from this in systematic ways, which a controlled experiment with $N = 208$ students (ages 11–19) across seven corridor configurations was designed to quantify.

Three behavioral patterns emerged as significant friction sources absent from standard models. *Social clustering*: peer groups move as cohesive units, reducing usable corridor width and creating correlated routing decisions. *Attentional friction*: smartphone use slows reaction time and produces local density peaks. *Corner-clipping*: students cut the inside of turns, concentrating density where corridors are narrowest. The measured free-walking speed was $v_0 = 1.47$ m/s ($\sigma = 0.19$); all three effects were incorporated as calibration parameters in the models below.

GRAPH-THEORETIC FLOW MODEL

The BIM architectural drawings were converted into a weighted directed graph ($|V| = 388$, $|E| = 427$), and the school timetable used to simulate over 52,000 weekly origin-destination pairs with Dijkstra routing, yielding a corridor-load profile for every lesson transition across a full school week.

As shown in Figure 1, **62% of all pedestrian traffic** passes through a single central hall – a bottleneck imposed by topology. A Simulated Annealing optimizer then searched thousands of room-allocation configurations to minimize corridor-load inequality; the Gini coefficient shifted from 0.585 to 0.568, a 3% reduction. Scheduling can redistribute load only at the margins.

This matters for a current decision: the administration plans to close the outer staircases, considering them redundant. The model shows this would force more inter-

floor traffic through the central hub, substantially worsening the bottleneck.

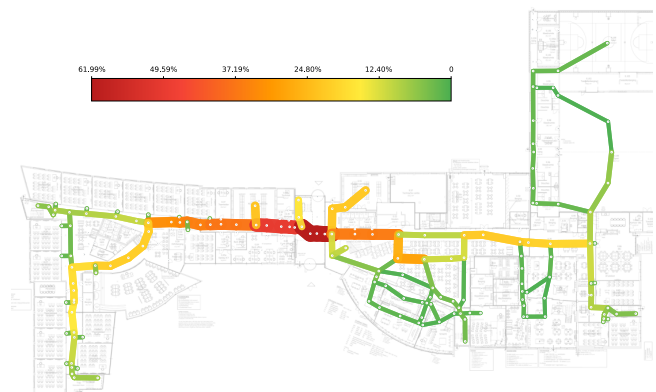


Figure 1: Simulated corridor load on the ground floor during a peak lesson transition (green: low, red: high). The central hall is the dominant convergence point.

MICROSCOPIC SIMULATION FRAMEWORK

Graph models quantify where load accumulates; they cannot capture how congestion develops physically: queue formation, doorway conflicts, or the propagation of density waves through a corridor. A second simulation layer addresses this using *JuPedSim* (C++/Python), a research-grade agent-based simulator in which each student's motion is governed by the Social Force Model, calibrated with the behavioral parameters from the experiment.

A key contribution is a custom geometry framework that encodes the building in an object-oriented representation parsed directly from BIM or CAD files, serving as a single input to both the graph model and the microscopic simulator. Since *JuPedSim* does not support multi-floor buildings, one simulation runs per floor in parallel; custom stair-transition logic transfers agents between floors, and a cross-floor visibility graph handles global routing. The real timetable then drives agent injection, enabling complete lesson-transition scenarios.

VALIDATION AND OUTLOOK

Once the building is in use, on-site pedestrian counts will be compared against the model's predictions, giving a direct empirical test of the pre-occupancy framework. Few studies have been able to validate crowd simulation predictions against ground-truth measurements in a school environment; the planned occupation of this building offers an uncommon opportunity to do so.

The methodology developed here, from floor plan and schedule to quantitative congestion maps, is designed to be reusable. Any building where movement is structured by a timetable, whether a school, hospital, or transit hub, can be analyzed with the same pipeline before construction decisions become irreversible.

Full write-up and posters → <https://hallways.leis.ink>