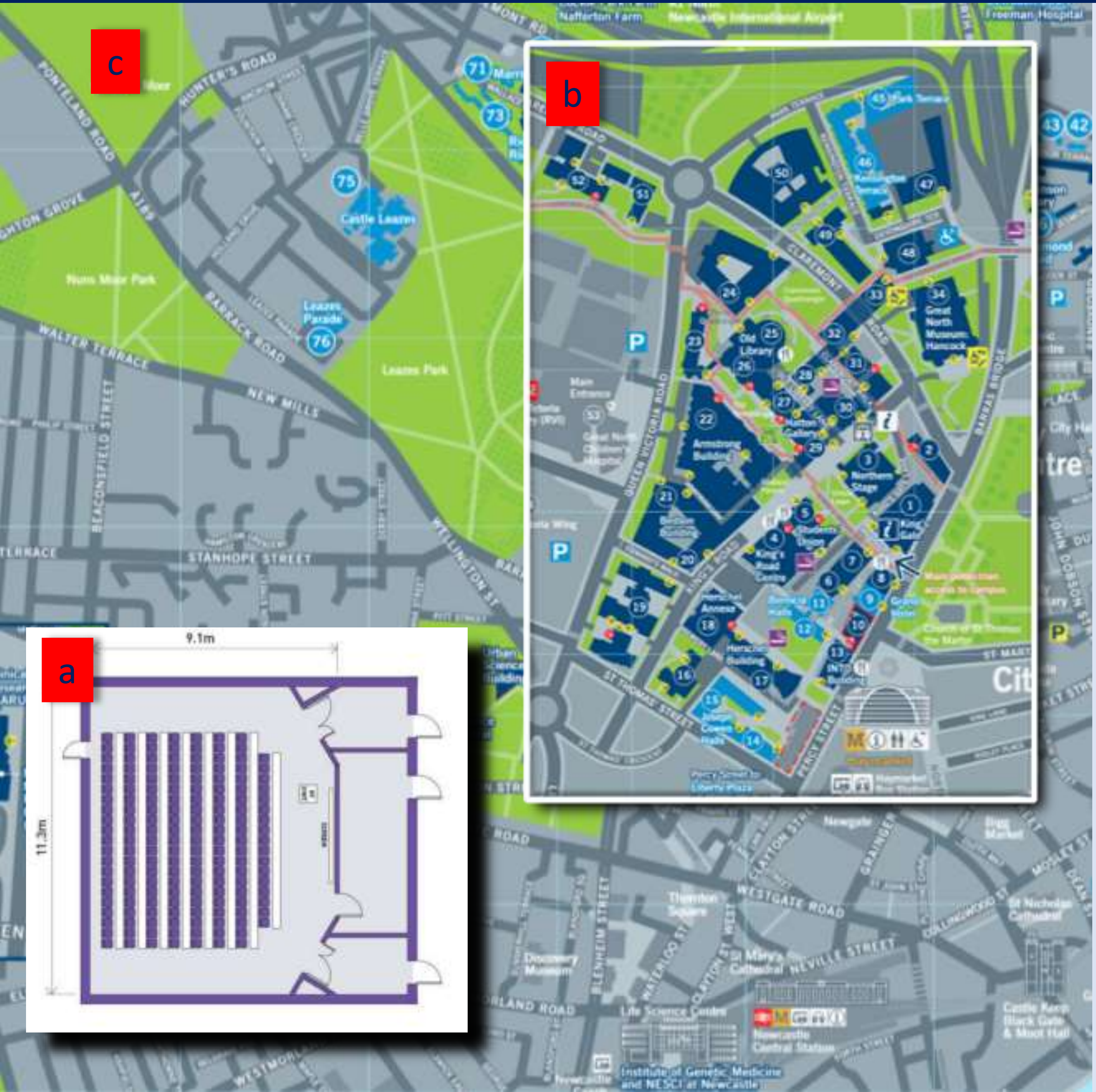
A summary of the V-KEMS Workshop on Unlocking Higher Education Spaces - What Can Mathematics Tell Us?



Universities are planning reopening

Public health guidelines and laws exist to ensure safety of staff and student behaviours.

University estate and activities need to work within these guidelines.

The spatial scales that are considered are a) building, b) campus and c) community.

An overarching principle discussed was:
"Online first and in-person where justified"

CAVEAT: this report contains preliminary findings that have not been peer reviewed. The findings are intended to provoke further study and policy discussion and should not be treated as definitive scientific advice in response to the SARS-CoV-2 epidemic. See full warning text in the final report.

1. Request: Relative risks for staff and students.

Assumptions:

Calculations use data from England only.
Chances of catching COVID19 do not differ by age.
Uses the same incidence and death rates as in the general population.
Calculations assume COVID will not be caught twice in short term.
Does not directly model super spreader (concentrated) events.
Note, most people who catch COVID19 will recover.
Note, IRL infection rate went up much faster than it came down.

Limitations and caveats:

No other factors are accounted for. Reckless intent not considered.

2. Summary:

Overall: Largest impact on operations may be those isolating from track and trace not the number of expected infections/illnesses directly.

Relative risks of death (would expect none or a very low number):

Age: Chances of dying go up by a factor of 10 for every 20 years, all staff have significantly higher risk than average students by up to 62x

BAME: Not yet clear, some evidence occupation is a factor for catching and then death, suggests for students this may be a less important factor.

Gender: Males have approx. double risk of death across all age groups.

Pre-existing health conditions: Higher risk suggests up to 20% of students will need to be given option for entirely online learning.

3. Graphical Summary

Weekly impact on one university of two different community infection rates. Total infected in a university community in any one week is relatively small, but track, trace and isolate could have a more significant impact.

June incidence rates are plateauing, May rate is the earliest calculated.

Infection rates from June 2020	Count	Have been infected	Uninfected to date
Staff only	6000	378	5622
Students only	27215	1715	25500
Students and staff	33215	2093	31122

Weekly infections using June 27th rate	Infections per week	Infections per Semester	Deaths per Semester	TT&I England actual 7:1	Isolations per Semester	Instantaneous isolations
Staff only	3	39	0.900	21	273	42
Students only	14	177	0.117	95	1238	191
Students and staff	17	216	1.02	116	1511	233

Weekly infections using May 11th rate	Infections per week	Infections per Semester	Deaths per Semester	TT&I England actual 7:1	Isolations per Semester	Instantaneous isolations
Staff only	5	62	0.900	34	437	67
Students only	22	283	0.117	152	1981	305
Students and staff	27	345	1.02	186	2418	372

Number of infections if controlled is low, however number of track and trace isolations is high over semester and up to ~400 in any one week in one semester assuming 14 day isolation.

Note peak community infection rate in UK in April was not estimated but likely at least twice the high rate used for May

Group	Count	Have been infected	Uninfected to date
Staff only	6000	378	5622
Students only	27215	1715	25500
Students and staff	33215	2093	31122

If semester length is taken as 13 weeks, calculations of number affected are first presented at the low June rate and then at the medium May rate.

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The impact across all staff is estimated to be relatively low, if staff take two weeks to recover and return to work on average there would be 6 staff ill at any point in time (weekly infections * 2).

The estimated number of deaths is very low and is likely to be linked as it is in the community to pre-existing known conditions, providing a mitigation route.

The largest impact will be the number of staff and students isolating because of positive case contact. Instantaneously this could be 42 staff, and it is feasible they will be in hot spots of infection rather than spread evenly across the university. Similarly, there could be a large impact on availability of students with up to 191 instantaneously isolating.

Given the uncertainties around the actual level in the community of the virus in the Autumn, the routes to infection and compliance with mitigation the estimated proportions isolating (and/or ill) above suggest it is important for operational continuity that staff and students are able to deliver and receive online teaching as a core baseline. Where face-to-face present-in-person teaching is delivered the public health mitigations and likely compliance need planning carefully.

Nick Holliman, Newcastle

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Building level (Group 1)	Campus level (Group 2)	Community level (Group 3)
Flow in buildings	Size, membership and leak-age of student bubbles	Public transport flow and bottlenecks
Loading and unloading	Flow on campus	Freshers flu and commu-nity?
Small space management and scheduling	Difference between student / non-students / visitors	Employment – long range interactions

1. Building based modelling – lectures, seminars, tutorials, labs, cleaning, corridor flows.

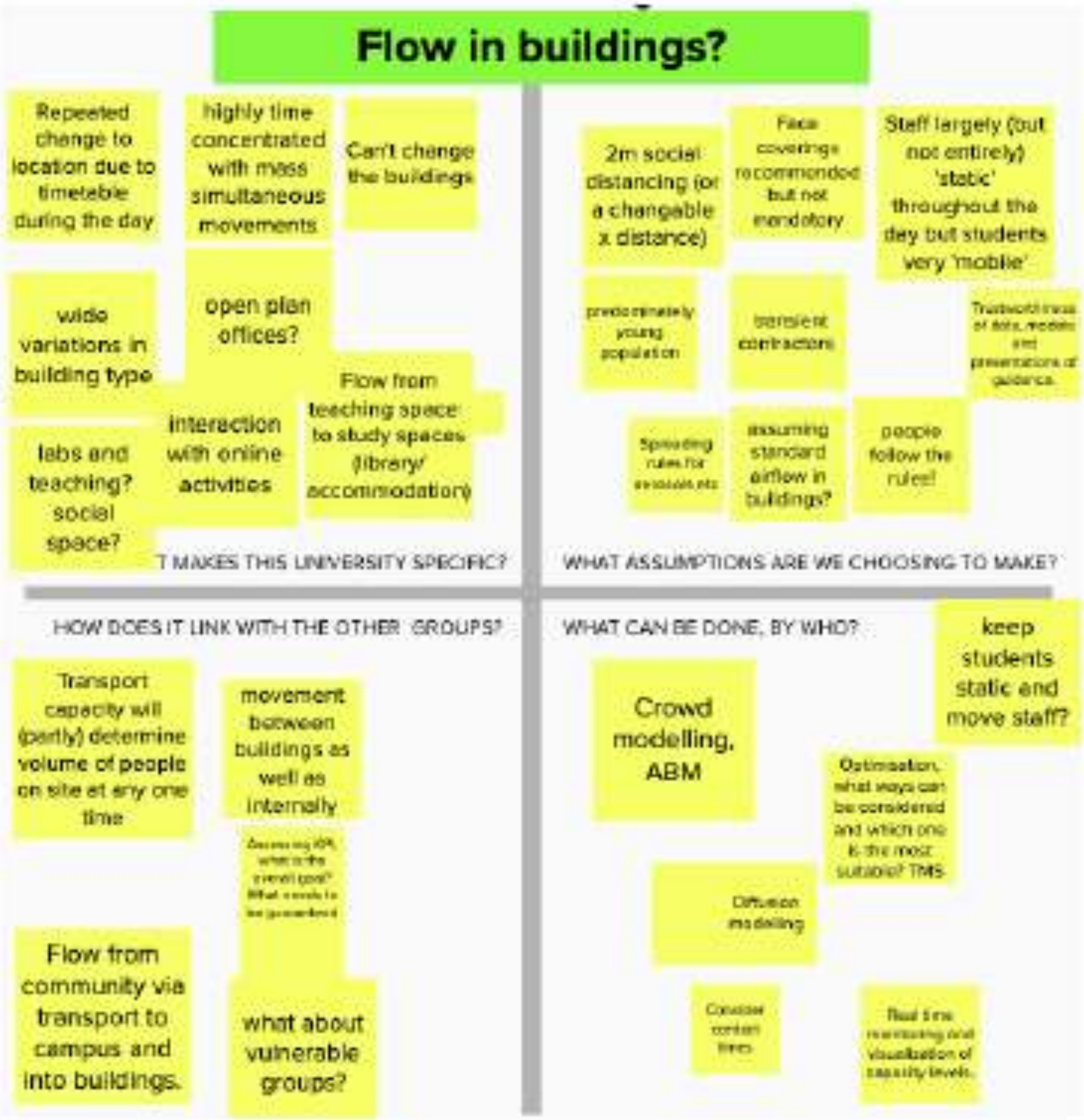


Figure 1: Example of mural exercise.

Read with reference to V-KEMS report: Unlocking Higher Education Spaces - What Can Mathematics Tell Us?

1. Request: **How should 2hrs teaching per week be delivered in time**

Assumptions airborne transmission scenario results are calculated with:

One infectious person initially in the room.
2 hours in person teaching per week by same staff member.
Social distancing at 2m (16 students) or 1m (28 or 44 students).
Model: one staff member and 5 to 32 students in the space.
Primary activity: lecture or seminar with a range of people talking.
2 hours in person teaching per week by same staff member.
Smaller class size N reduces infection rate I, since I is proportional to N^2

Limitations and caveats:

No other factors are accounted for. Reckless intent not considered.

2. Summary:

Options modelled:
a) One 2 hour class
b) Two 1 hour classes 48 hours apart
c) Three 40m classes 48h apart

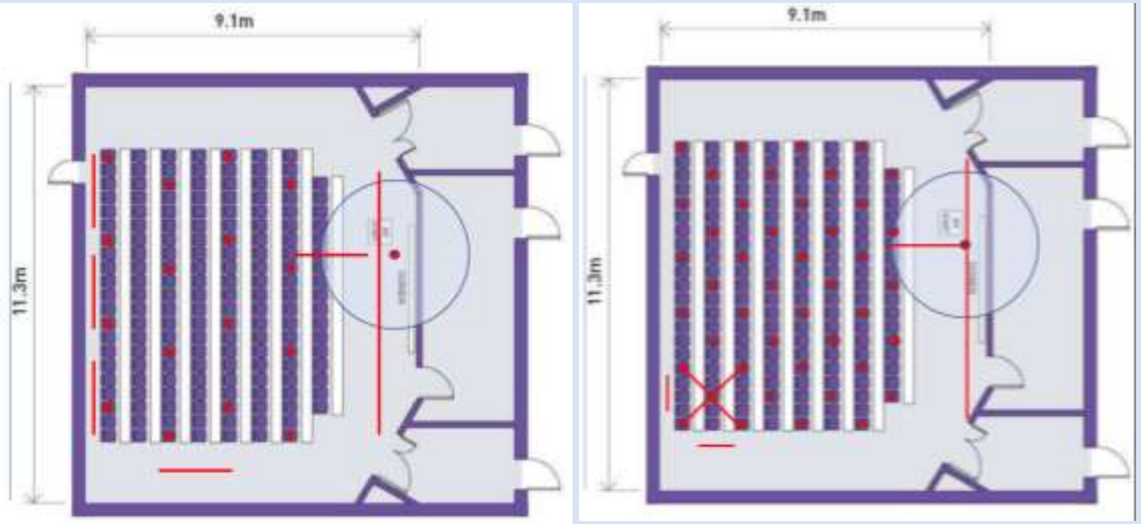
Best worst case choose a)
-assuming variable teaching activity & variable social distancing.

Best for low density, standard lecture levels of talking choose c)
-assuming 16 in room i.e. 2m social dist (range 0.5 to 1.5 new cases/wk)

Best for higher density, active seminar levels of talking choose a)
-assuming 32 in room i.e. 1m social dist (range 6 to 9 new cases/wk)

3. Graphical Summary

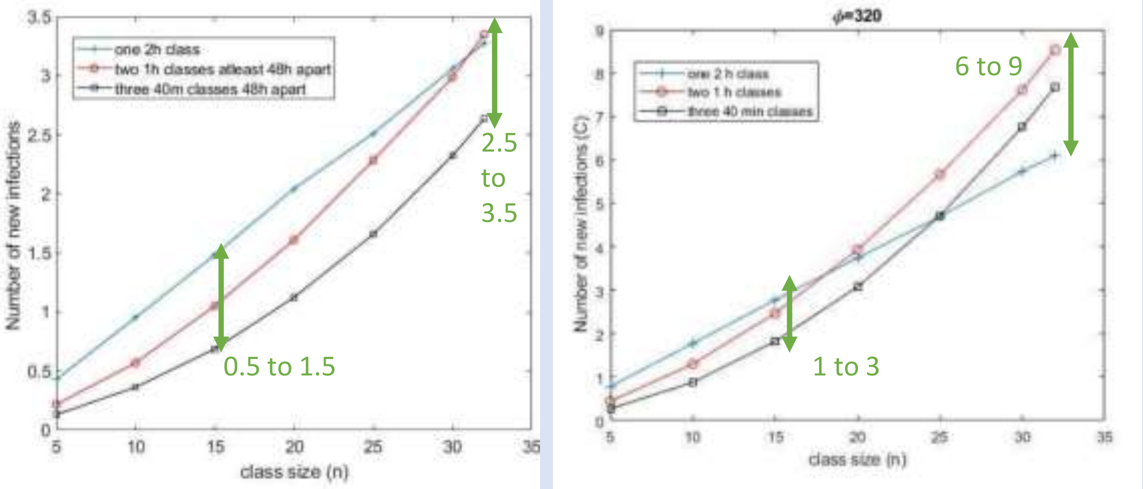
164 seat lecture theatre fits 16 students (10%) at 2m soc. dist.



or up to 44 students (27%) at 1m soc. Dist.

Lecture levels of talking

Active seminar levels of talking



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1. Request: How does surface cleaning strategy affect infection rates

Assumptions surface transmission scenario, results are calculated with:

- Surface infection decay rates are at least over hours at room temperature.
- Surface cleaning important, ideally needs a couple of hours before reuse.
- 40 students in class moving via shortest path to their seats.
- Students could touch any surface on their way. (prob = 0.5)
- Students clean their area at the start of a session (prob = 0.9)
- Transmission from touching surfaces (prob = 0.1)
- Rooms are professionally cleaned every 8 hours at end of day.

Limitations and caveats:

No other factors are accounted for. Reckless intent not considered.

2. Summary:

- Lecture length 30, 60 or 90 minutes.
- Cleaning, none, alternate row position, clean at end, pro-clean at midday

Best worst case if no cleaning during day

Alternate row locations in 90 minute lectures.

Better cases with cleaning strategies

Add student cleaning at end of each session as well as beginning
or add pro-cleaning by staff at midday

Note there is a balance between mitigating airborne and surface transmission modes – cleaning strategies important.

3. Graphical Summary

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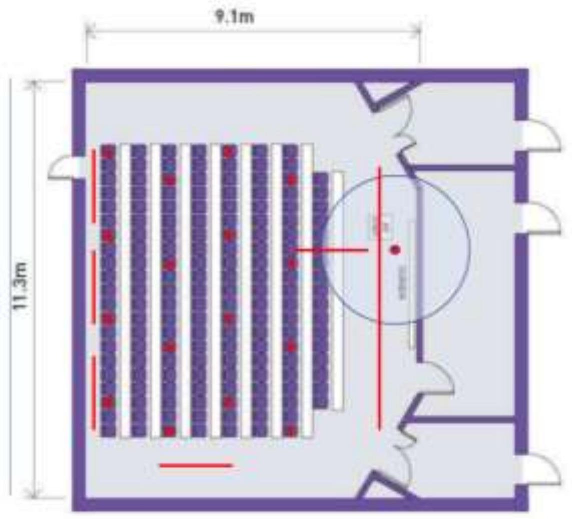
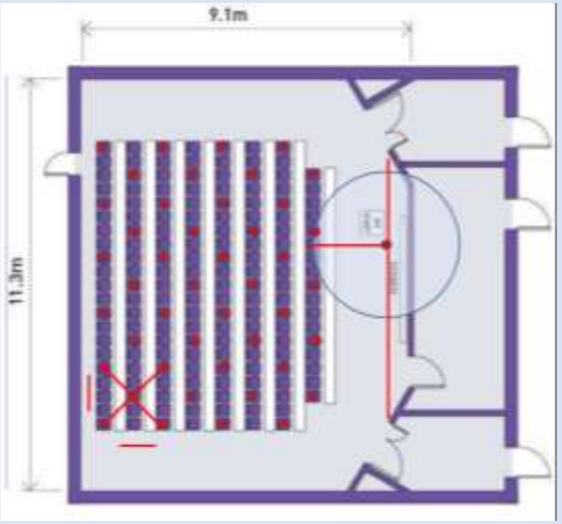
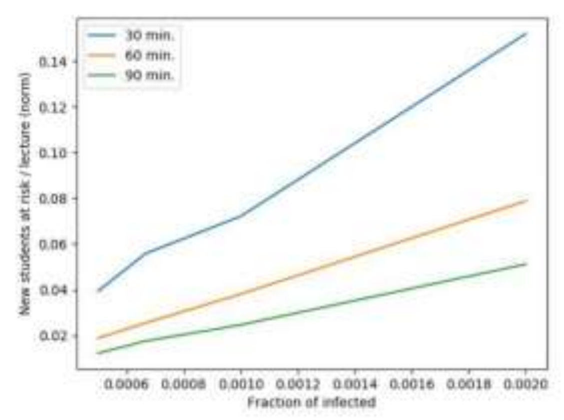


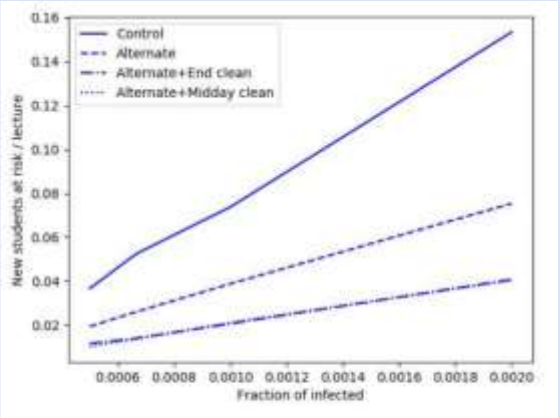


or up to 44 students (27%) at 1m soc. Dist.

Effect of lecture length



Effect of cleaning



Read with reference to V-KEMS report: Unlocking Higher Education Spaces - What Can Mathematics Tell Us?

1. Request: Is there capacity to give every student PiP time weekly?

Assumptions for present-in-person (PiP) modelling:

Based on 1 weeks teaching data from Warwick.
682 modules considered that have from 521 to 1 students registered.
256 rooms from 500 tiered seats to 3 flat floor seats.
Capacity reduced to 10% in tiered seating and 30% in flat floor, 2m rule.
Limit to 25 people per room for modelling purposes, affects 14 rooms.
One, 1 hour PiP session per 20 credit module per week (3hrs total).
Assume opening hours 9am-8pm for 5 full days=> available 40 to 55 hours

Limitations and caveats:

No other factors are accounted for. Reckless intent not considered.

2. Summary:

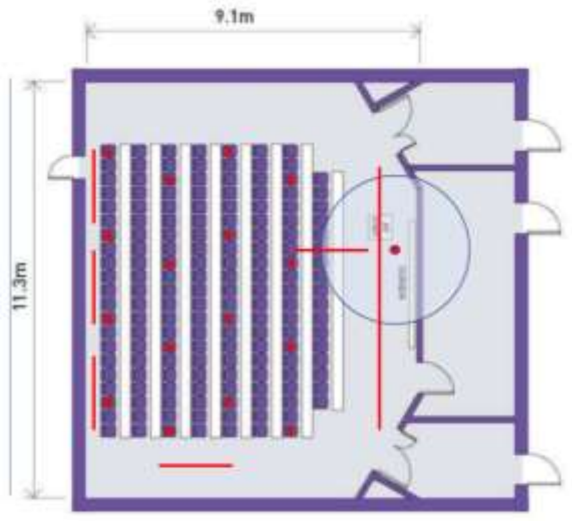
The table below shows the capacity being used in each scenario.

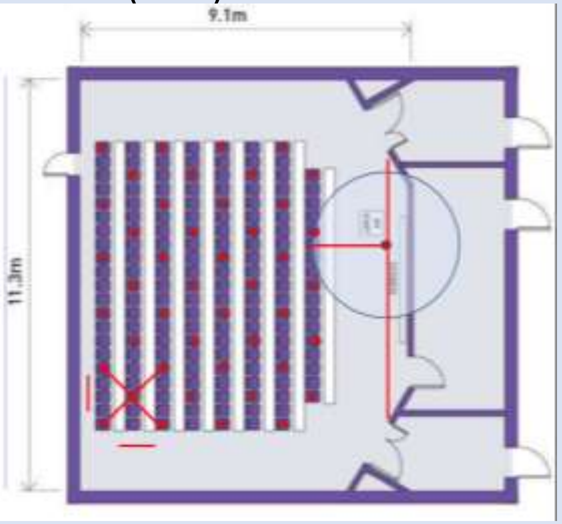
Weekly hours	Max 25	Max 15	Max 10
55 hours	48%	54%	65%
40 hours	67%	76%	90%
30 hours	90%	NA	NA

Dividing by years would reduce number of students using same space.
Reduce movements by ideally keeping students in one room for all sessions.
Wipe down before and after sessions, then leave for two hours (RAMP), eg alternate layout patterns every session.

3. Graphical Summary

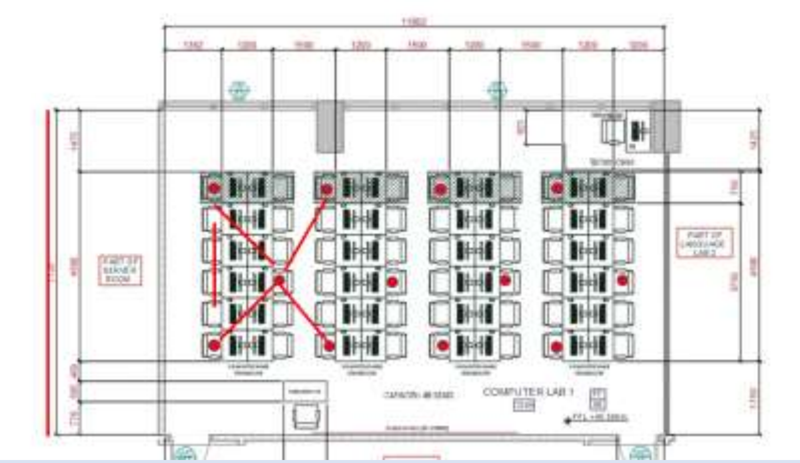
164 seat lecture theatre fits 16 students (10%) at 2m soc. dist.





or up to 44 students (27%) at 1m soc. Dist.

A 48 seat computer lab at 2m soc. dist. has 12 (25%) occupancy
Staff cannot approach closer than (2m or 1m) to help students.



Read with reference to V-KEMS report: Unlocking Higher Education Spaces - What Can Mathematics Tell Us?

1. Request: Dynamics, modelling movement between and into rooms.

Assumptions for dynamics modelling:

Model movements between rooms along corridors.
Model movements into/out of a room.

Limitations and caveats:

No other factors are accounted for. Reckless intent not considered.

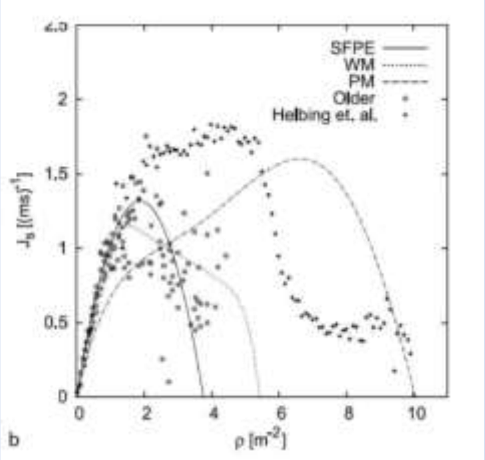
2. Summary:

Fast movement in corridors is relatively safe (VSG2)

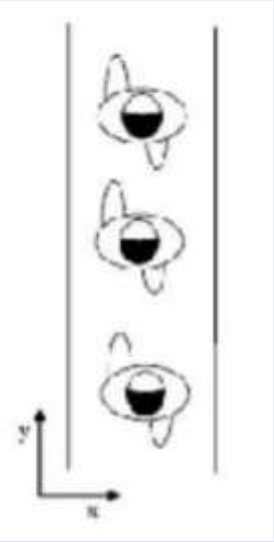
Bottlenecks can be more dangerous – but as long as people strictly remain socially distanced there will be no bottlenecks and a 24 person lecture theatre can be emptied in about 3 minutes with 2m soc. dist.

3. Graphical Summary

Fundamental diagram right suggests all models reach a peak flow that is similar, but at different densities



Corridors with fast movement relatively safe.



Bottlenecks as below can be avoided if people stick to social distancing rules.

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2. Campus based modelling – bubbles as a mitigation, flow bottlenecks on campus.

Read with reference to V-KEMS report: Unlocking Higher Education Spaces - What Can Mathematics Tell Us?

1. Request: How well can social bubbles work as a mitigation?

Assumptions for bubbles

Living on-campus in university accommodation.

UG students with shared timetables and small classes.

Freshers aged 16-18 having no existing relationships across years.

Limitations and caveats:

No other factors are accounted for. Reckless intent not considered.

2. Summary:

Operation of bubbles

Each bubble is housed and taught together.

Infected bubbles are isolated immediately.

Food is delivered to residences (no shopping).

Students must use on-campus facilities only (shops, clubs).

Best worst case bubble size

Smaller bubble sizes ~12 withstand higher rates of R in the community.

Smaller bubbles will isolate fewer students for each infected student.

High testing rate needed if social bubble compliance is not high.

Future options to model

Bubbles of bubbles may be a reasonable strategy in low R situations

3. Graphical Summary

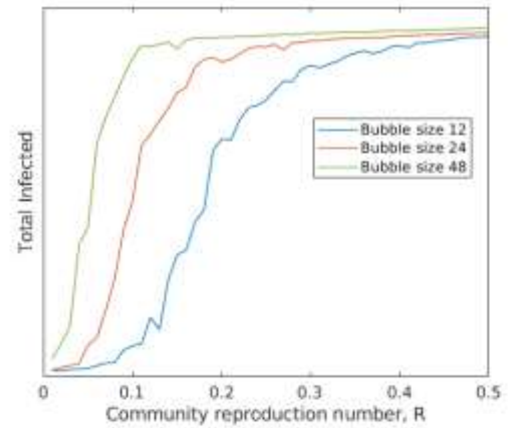

Figure 10: y-axis values are omitted, as the exact impact of bubbling scenarios depends on the underlying parameters. This initial analysis should be seen as exploratory and providing qualitative results, not an accurate quantification of the relative benefits of different bubble sizes. Results are averages over 50 simulations.

Smaller bubbles result in lower impact of high R per bubble.

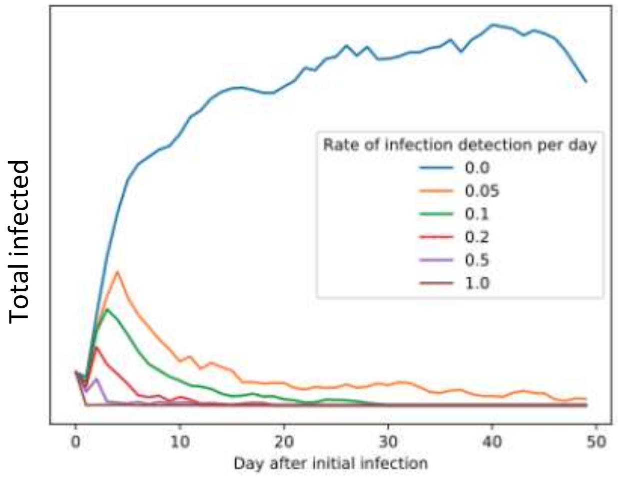

Figure 11: 128 bubbles of size 12 with 100 extra-bubble contacts

Testing and isolating bubbles important to reduce overall outbreak size.

More testing and isolating reduces impact.

Read with reference to V-KEMS report: Unlocking Higher Education Spaces - What Can Mathematics Tell Us?

1. Request: Do bottlenecks form in flows around a campus?

Assumptions

Simple model of two way flow eg between buildings A and B.
Or from building A to bus station B.
Flow goes through one choke point C on the way.

Limitations and caveats:

No other factors are accounted for. Reckless intent not considered.

Note, little existing literature on this problem most is about emergency exit only.

2. Summary:

Best worst case

Limited advice is possible without specific scenario data, however staggering movement times can have benefits.
For example, stagger the ends of lectures so every group does not flood the campus at the same time.

Remote campus based universities need to consider bus timetable capacity on socially distanced buses and the lecture timetable.

3. Graphical Summary

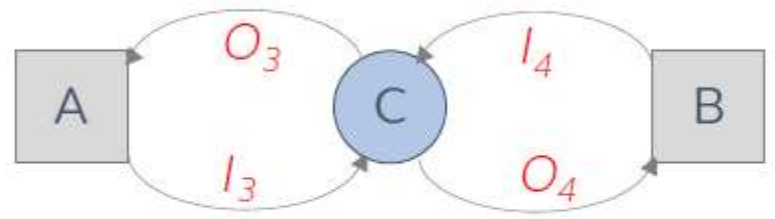

Figure 19: Simple model with labelled nodes.

A –a building
C - a choke point on the route from A to B
B a second building or bus station

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3. Community modelling – transmission to the community, transport issues.

Read with reference to V-KEMS report: Unlocking Higher Education Spaces - What Can Mathematics Tell Us?

1. Request: Minimising infection transmission from Uni. to community?

Assumptions

As noted age is a major factor in severity of COVID infection outcomes.
Universities are large communities with a risk of infection outbreak.
In the absence of random testing such an outbreak can remain hidden.
Impact on staff and community likely to be larger than on students.

Limitations and caveats:

No other factors are accounted for. Reckless intent not considered.

2. Summary:

Incentivise COVID safe behaviours among staff and students.
Testing to detect outbreaks e.g. of 20 or less will keep seeded infections down in university households, there is no specific cutoff more testing is good.

Best worst case mitigation

Implement in-house random testing – high rates e.g. all, up to twice a week.
Basic test-isolate policies can lead to one third in isolation at any time.
Include testing of contacts after incubation period to reduce isolation times.

3. Graphical Summary

Contact network of potential types of university-community interactions by activity type.

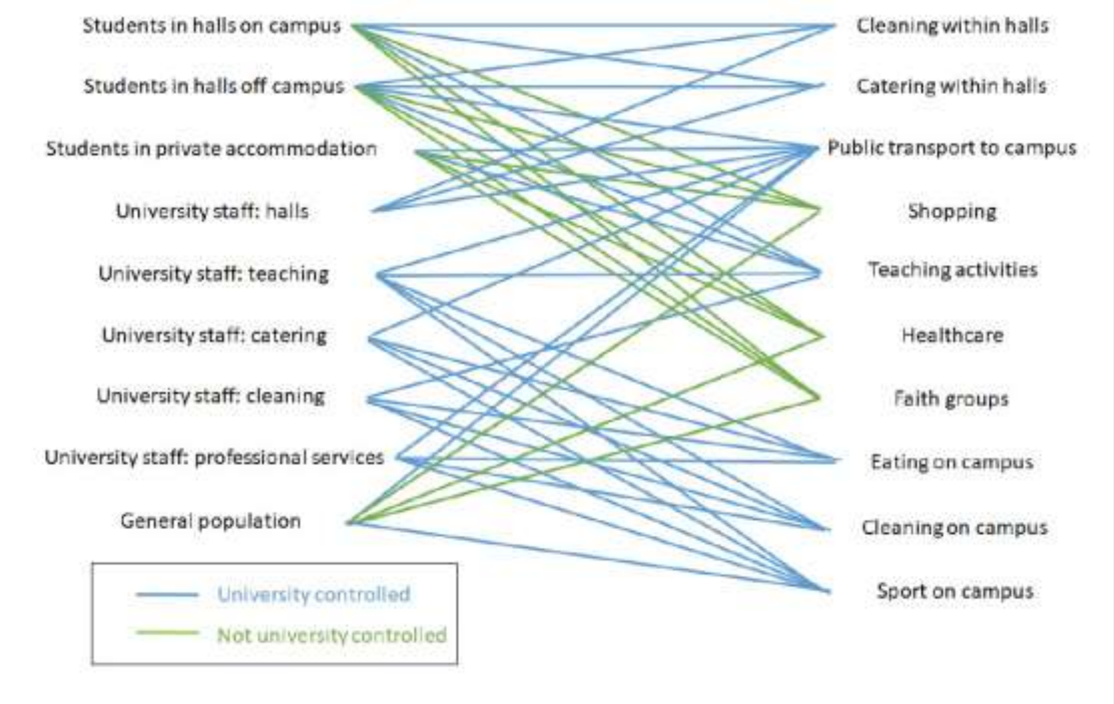
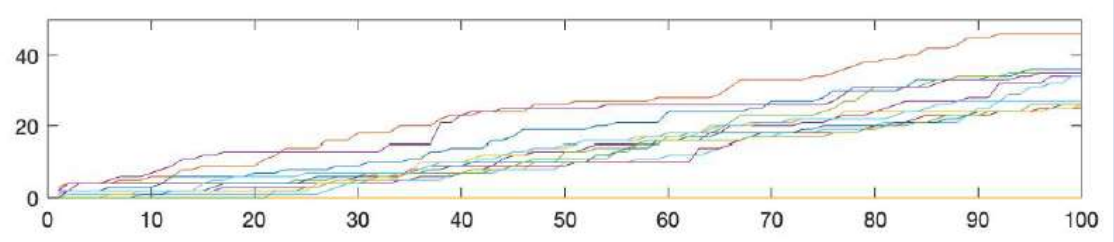


Figure 20: Schematic contact network



Number of seeded new infections (vertically) against number of cases that can be detected by random testing for bubble sizes of 10.

Read with reference to V-KEMS report: Unlocking Higher Education Spaces - What Can Mathematics Tell Us?

1. Request: How does transport interact with the infection rate?

Assumptions

Public transport a source of infection to and from the community.
Need to account for socially distanced transport capacity.
Severity of the issue varies significantly between universities.
More car parking may be required with a reduction in shared journeys.
Weather in winter is very likely to impact on walking/cycling preferences.

Limitations and caveats:

No other factors are accounted for. Reckless intent not considered.

2. Summary:

Most university timetabling systems would find it hard to match lecture slots to likely bus arrival times.
There is lots of data in some cities/universities but currently few models to help bring this together.

Best worst case mitigations

Confirm capacity is sufficient especially with any working hour changes.
Reliable real time arrival information could help reduce congestion.
Encourage walking and cycling (more safer patrolled cycle parking?).
Ensure internet at home and on campus is tested for capacity.
Socially distanced study spaces on campus for waiting times.

3. Graphical Summary

Example: York has a mixture of plenty of on-campus accommodation for first years and heavy reliance on public transport/own transport for off-campus students and staff.

Buses become mixed university and community use as they go into the city.

Student comments – notes from a conversation with an ex student union president.

1. Request: Can you help give a student viewpoint on re-opening?

Bruce Wight, former Student Union President, Aberystwyth

Student aims: vary widely between education, sports/clubs and social life, how to support all three.

Bubbles: in first year make most sense, by course and accommodation, likely to be harder to maintain them over time though especially if social interaction, societies and sports increase.

Freshers fair: traditionally a very important event to support to integrate and find social groups, unclear how this can be socially distanced but it is important.

Community Interaction: a high number of students will have jobs in the community, as well as social interactions. This could be a route for infection spread each way.

Communication: good links from SU to the University and the VC essential in ensuring a common message and understanding is developed.

Study space access: these play an important part in life for people working in shared houses and on research projects. Home internet is not always high performance for example.

Online teaching: seen as something to be endured, better delivery systems and production perhaps needed to improve this.

Weird timetables: normally might be an issue but with right communication should be understood. Balance use of face to face if it is perceived to be an advantage.

Consistent messaging: important across social and physical media from the union and the university.

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This Virtual Study Group was hosted by the:
Virtual Forum for Knowledge Exchange in the Mathematical Sciences (V-KEMS)
consisting of
Knowledge Transfer Network (KTN)
Isaac Newton Institute (INI)
Newton Gateway to Mathematics
International Centre for Mathematical Sciences (ICMS)

Knowledge Transfer Network

Isaac Newton Institute for Mathematical Sciences

ICMS

Newton Gateway to Mathematics

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