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THE IMPACT OF SPATIAL DESIGN ON THE LEARNING PROCESS AND STUDENTS' SOCIALISATION:

A Study of Secondary Schools Within the UK

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ABSTRACT

The last century has witnessed an evolution in our understanding of learning from being a spoon-feeding process towards a process based on the ability of the human mind to receive information, construct knowledge and gain understand according to the learner's perceptions (Brown, 2004). However, the spatial relation between the learning process and the physical environment is less well understood. This research attempts to focus on learning in schools, while aiming to understand the spatial impact of the building design on the students' learning process. The academic life of students inside the school premises is deeply entangled with social patterns. Consequently, the research considers the spatial dimension of both learning and socialisation of the students. Nine secondary schools in the UK are presented as a comparative case study based on quantitative analysis of the school buildings. Space syntax analysis is the key criterion of evaluation, supported by studying the organisation of various spatial components (circulation, courtyards, social and learning spaces). The research highlights the important role of the spatial design and configuration. The paper explains the spatial potential within the school building design that is argued to stimulate the students' socialisation patterns. Moreover, it unveils the potential within the spaces that contributes to students' learning, while focusing on how the design of the learning spaces and their layouts could accommodate the learning process inside the school. The results of studying the nine school buildings show that there is a moderately strong correlation between the syntactic measure utilised in the analysis (Visual Mean Depth) and the performance of the students within each school. The study proposes that the configurational analysis should become part of the original school design process to help understand the possibilities of the students' social activities and mixing patterns. Additionally, it is concluded that learning spaces should be designed to afford various learning formats, not to be limited to the typical classroom layout.

KEYWORDS

School Buildings - Spatial Configuration - Students - Learning - Socialisation

1. INTRODUCTION

According to Bill Hillier, the generic function of every building is to initiate, facilitate and accommodate movement patterns by the users (Hillier, 1996). Movement then leads to patterns of co-existence which evolve into users' social interactions (mixing, socialising, etc.). While spatial design and configuration play an important role in triggering the users' movement, they also affect their interaction patterns and social behaviours. This proposition has led to a rich and varied research programme using Space Syntax theories and its analytical tool Depthmap, which generates different syntactic measures (Choice, Integration, Visual Mean Depth, etc.). Following the generic function of movement, which Hillier has conceptualised as the first filter separating real buildings from the unlimited possibilities of form, Hillier suggested a secondary filter which is the programmatic requirement of the building (Hillier, 1996). In simple words, it is the function or service the building is meant to provide for the users which is (for most of the users) the primary purpose of the building; learning in a school or exhibiting in a gallery. The question here is: what is the impact of the spatial design and configuration on this function and to what extent does the design impact the fulfilment of (what most people perceive as) the main function of the building?

In order to investigate this, research cannot be generic for all types, but rather focuses on one type of buildings. This research studies the design of secondary schools, and the relation between space and the learning process as well as the students' social life. The main hypothesis of this research is that the spatial design and configuration of a school building impacts the students' academic performance. To test this hypothesis, nine different secondary schools all situated inside the UK were used as case studies. In addition, the performed analysis aims to evaluate the school buildings and help understand the potential of space to 'afford' the learning process and facilitate the students' socialisation patterns. The term affordance is actually introduced by Gibson (1979) as the possible actions that might occur in relation to an object or environment, so in return, this object (or environment) affords this action. For example, a chair affords sitting. Within the school building context, affordance of the learning process is the level by which space is flexible to accommodate the format of learning taking place and not to obstruct but actually to facilitate the students' ingestion of knowledge. Space is also meant to afford, facilitate and trigger the students' social interaction inside the school building.

To understand the relation between the three main factors (space, socialising and learning), this paper is structured as follows: the literature review will discuss how learning is conceptualised based on research in the field. The methodology section will illustrate the analysis of the nine school buildings and explain the metrics used. After that, the paper will utilise the syntactic analysis to evaluate the spatial performance of the buildings and focus on understanding the affordance of the school building for social encounters and learning. Results are discussed and a final concluding section will highlight limitations as well as future research plans.

2. LITERATURE REVIEW: PERCEPTION OF THE LEARINNG PROCESS

Society's views and understanding of the learning process has evolved over time. Markus (1993) proposed that schools and systems of education have always mirrored modes of economic production. Sailer (2015) summarised Brown's description of learning in the nineteenth century as a spoon-feeding process mainly concerned with injecting the learners with knowledge and information. In the twentieth century, this process was re-conceptualised by Vygotsky (1930) who argued that the learners' ingestion or comprehension of knowledge provided by the teacher is mainly dependent on their mental development. Furthermore, Vygotsky argued that the environment, physical and social, will impact the learning process. He gave the example of early learners' education and maintained that it is wrong to assume that a children's source of knowledge will be provided only inside kindergartens (Vygotsky, 1978). To complement this idea, Jonassen adopted constructivist conceptions of learning which declared that education cannot be transmitted. Instead, "knowledge is individually constructed and socially co-constructed by learners based on their interpretations of experiences in the world" (Jonassen, 1999, P.217). With the rise of the learner as the key player in the process of learning, the sociologist Bernstein (1973) explained that education will evolve from a strongly framed system into one with weaker boundaries. To explain this concept, Bernstein identified the curriculum content of learning as weakly or strongly classified, i.e. the degree of boundaries between the material being taught, and how they inter-relate. As for the method of learning, Bernstein described it either as weakly framed with much freedom for the learner, or in contrast, strongly framed with a high degree of control by the teacher over what is taught. Within these two concepts, school education could be sub-categorised according to whether it is course or subject based (Bernstein, 1973).

Moreover, Day and Midbjer discussed Piaget's ideas on learning as an interweaving network of relations. They clarified that "perception, action, interaction with others and reflection develop, modify and consolidate it" (Day and Midbjer, 2007, P.4). Brown also added the idea of learning as a "modification of behaviour brought about by experience" (Brown, 2004, P.6). Sailer (2015) further explained consequences for the role of the teacher who becomes an enabler whose role is to set the environment where the learners acquire knowledge themselves. She described this development in the learning process as a "shift towards a learner-centred view rather than a teacher- centred view" (Sailer, 2015, P.2).

In summary, social aspects are no longer a secondary factor in the background of the learning process, but actually a dominant factor that shapes the outcome of learning and should be carefully considered in the spatial design. It could be argued that learning becomes a social and behavioural process dependent on the physical environment as the context of learning; thus it occurs not only inside classrooms, but wherever there is a social interaction or behavioural experience. Thus, space, its configuration and organisation would possibly play an important role in the learning process.

Previous research has explored the role of the school building on attainment and learning outcomes (Tanner, 2009; Barrett et al, 2013), yet configuration did not feature explicitly in these studies. From a space syntax perspective, existing research has studied encounter patterns (Pasalar, 2003; Kishimoto and Taguchi, 2014) yet did not bring this together with attainment. Therefore, this research aims to fill a gap by investigating school buildings syntactically and analysing consequences for learning outcomes, but also linking a detailed configurational exploration with learning processes and socialisation more broadly.

3. METHODOLOGY AND DATASETS RESULTS

In order to investigate how spatial design impacts the students' learning and socialisation, the research compares nine school buildings, all designed and constructed recently by the same architecture firm; Feilden Clegg Bradley Studios. Plan material was kindly provided by the architects. The rationale for choosing buildings by one particular architect was to minimise the chances of having major variations in the design which might lead to variations in the programmatic functionality of the building. The nine buildings indeed have similar types of spaces. Still, the spatial organisation and configuration of the school buildings are very different. Figure 1 shows the footprint of the buildings as well as a summary of each of the nine school buildings including key statistics such as number of floors, year of completion, total area and total number of students.

School	A	B	C	D	E	F	G	H	I
Simplified outline									
Year of completion	2005	2012	2013	2013	2012	2007	2007	2008	2013
Number of Floors Excluding Mechanical/Electrical floors/rooftops	2	3	2	3	4	3	1	4	4
Total Area (sq.m)	10889	15214	8085	17094	15039	10063	5712	14077	15310
Location	Easton area, Bristol	Harold Hill, Greater London	Hastings, East Sussex	Marton, Blackpool, Lancashire	Ilford, London	City of West-minster, Greater London	Mansfield, Nottinghamshire	Liverpool Road, London	Greenford, Ealing
Total Number of Students	833	796	812	1097	630	1192	916	1163	375

Figure 1 - The Nine Secondary Schools

Each building was analysed in its configuration using DepthmapX (Varoudis, 2012). The first section of this paper will analyse Visual Mean Depth (abbreviated as VMD in the following), which is a syntactic measure that calculates the shortest visual path of a space to all other spaces within the same building. It indicates how integrated/segregated a space is, or how shallow/deep from the rest of the spaces. The lower the value is, the fewer visual turns, and thus the more visual integration. It is convenient to utilise as it measures the mean global number of visual turns to reach one specific point from every other point, and thus its values are comparable between different schools. The syntactic measures are exported into a Geographical Information System software (QGIS) to extract descriptive statistics for specific areas (Average, Minimum, Maximum, Standard deviation, Frequencies of certain values, upper and lower percentiles). An additional complementary measure used is Visual Step Depth (VSD), which shows how deep or shallow certain areas of the plan are from the entrance.

The second section of this paper will use the syntactic results plus data of the students' attainment to provide an evaluation of the school buildings and the learning process. However, since learning is argued (in the literature review) to be a social and behavioural process, students' attainment is only one facet of student's performance and the proficiency of the learning process inside the schools. That is why the third and fourth sections will attempt to highlight the spatial potential of a school by asking how it may facilitate or prohibit students' socialisation patterns (by analysing socialising spaces, i.e. all the gathering spaces, meeting areas and common rooms inside the building) and how it could afford the learning process (by focussing on classrooms, lecture halls, seminar spaces and workspaces).

4. THE SPATIAL CONFIGURATION OF THE NINE SCHOOLS: A SYNTACTIC ANALYSIS

This chapter will discuss the distribution of VMD across the schools (figure 2) alongside descriptive statistics (table 1) including mean VMD, standard deviation and minimum/ maximum values. Standard deviation highlights variation of VMD within the same building and is important to consider in addition to mean values, especially for high deviation. Furthermore, the maximum value acts as a critical threshold to indicate the visual segregation of some areas within the plan which might not be obvious when checking the average value.

The syntactic results reveal that school D has the lowest average VMD, lowest standard deviation and lowest minimum value. School F is the exact opposite (ranked 9th) with highest VMD figures, however school H shows the highest standard deviation. School C has average values compared to every other school. Figure 3 shows a complementary measure which is Visual Step Depth (VSD). This analysis marks the spaces which are more than three visual turns from the school entrance which are relatively deeper (segregated) than the rest of the school spaces considering the school entrance as a starting point of the journey.

School	Average VMD	Standard Deviation	Minimum	Maximum
A	4.05	0.71	2.45	6.50
B	3.59	0.87	2.36	6.68
C	4.04	0.60	2.66	7.10
D	3.11	0.56	2.19	6.69
E	4.45	0.84	2.86	9.20
F	4.79	0.75	3.09	7.81
G	3.64	0.76	2.27	6.41
H	3.99	0.90	2.47	8.69
I	4.47	0.77	3.05	7.50

Table 1 - Descriptive statistics for VMD of the Nine Schools

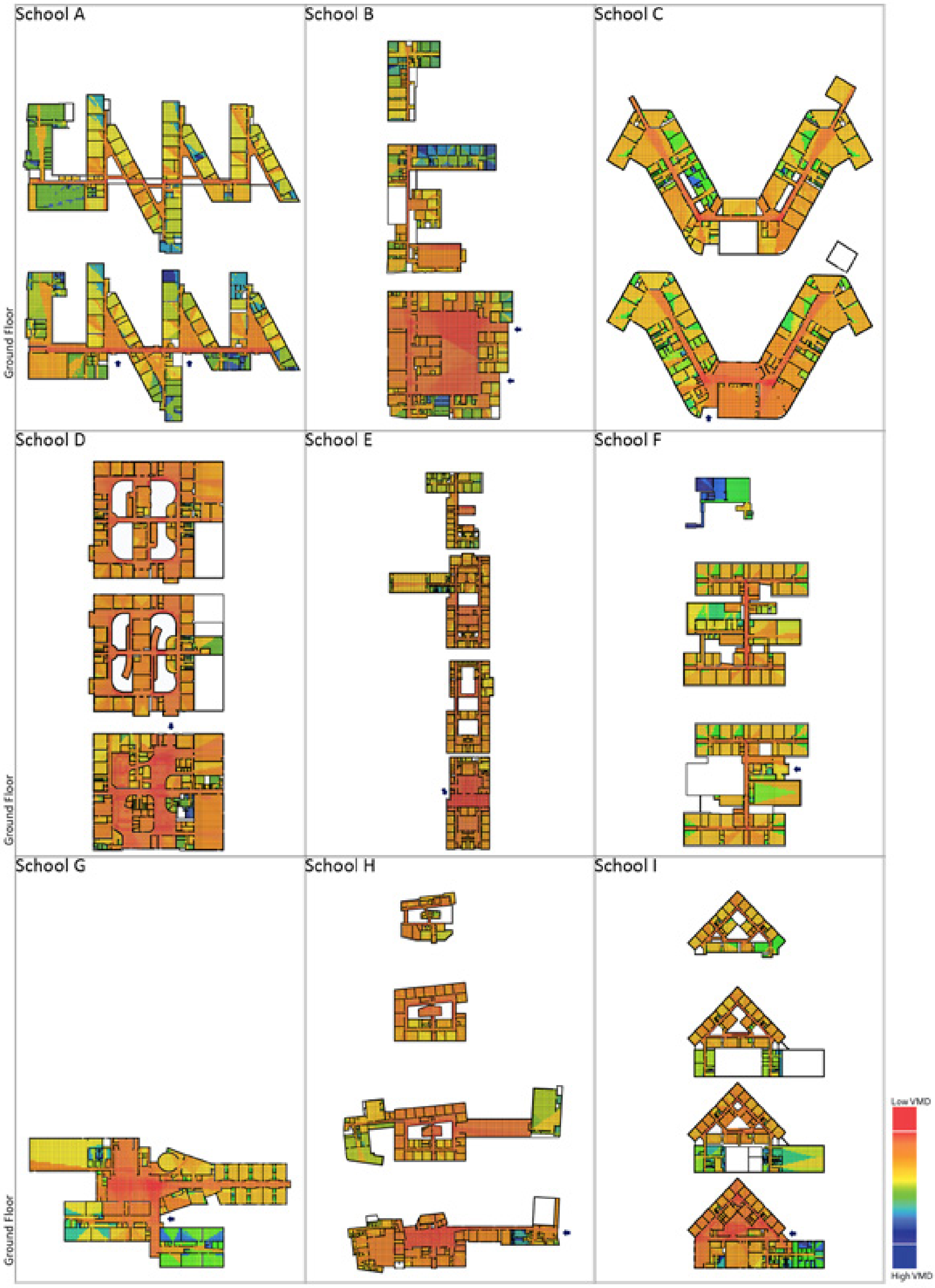


Figure 2 -Visual Mean Depth (VMD) of the Nine School Buildings (Entrance Marked with an Arrow)

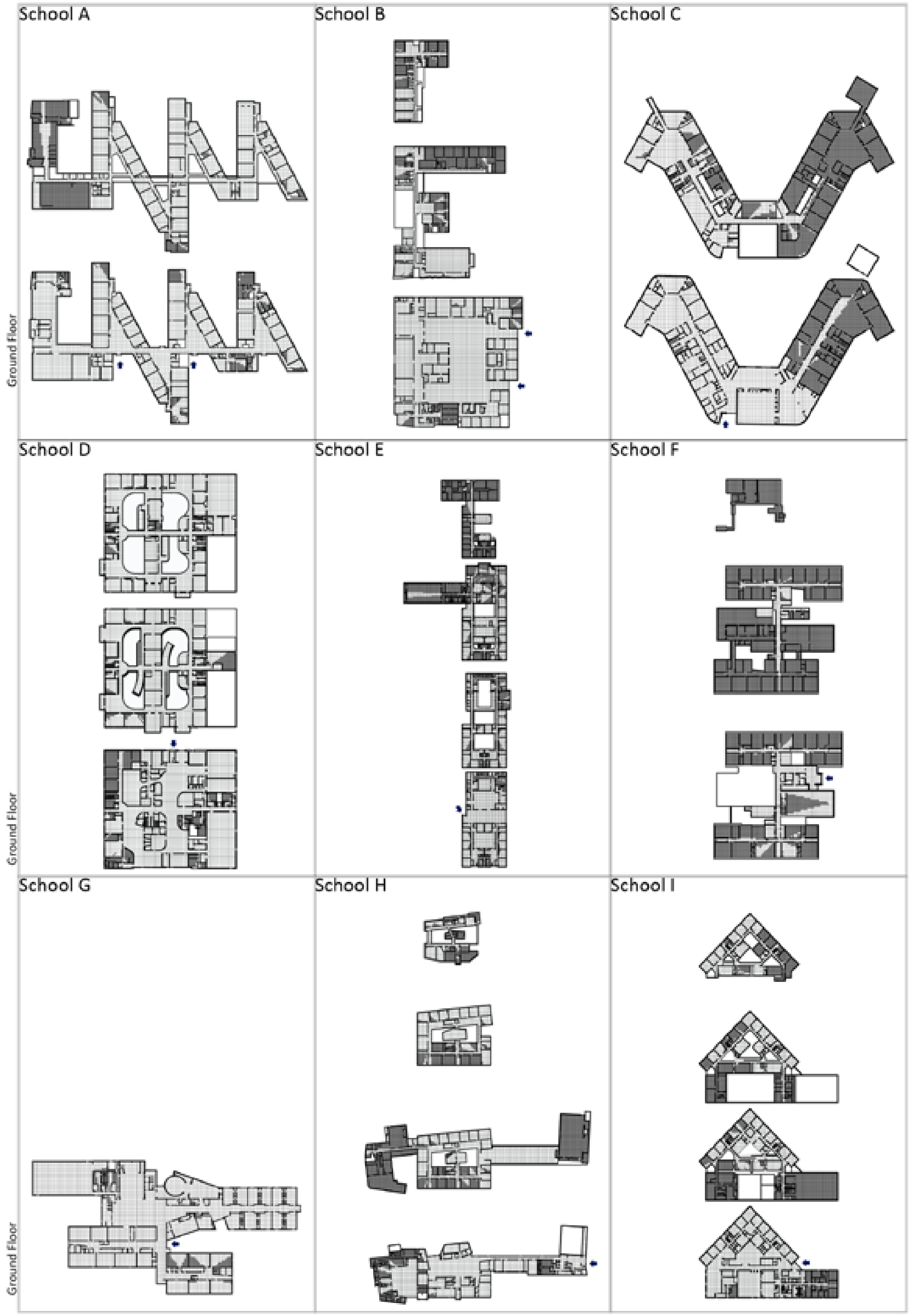


Figure 3 - Visual Step Depth from the Entrance. Dark Grey: More Than Three Turns. Light Grey: Less Than Three Turns

The following discussion includes comparative quantitative data of the spatial components of the school buildings. The most important spaces are the entrance location, circulation, courtyards and atria beside the main socialising spaces and classrooms. The attempt to focus on circulation spaces and courtyards is derived from the idea that learning is perceived as a social process not only occurring inside the classrooms but everywhere in the school building (Sailer, 2015). Studying these elements explains the differences between one design and another in terms of spatial organisation, which indicates possible strengths or weaknesses in the design of each school. The organisation of these components is linked to the overall spatial configuration of each building (one component would affect the whole building and the building would affect each component).

School A:

The primary horizontal circulation axis is the most visible route in the school, followed by the vertical secondary branches. The importance of the courtyard is portrayed in maximising the visual connection across the floors, still most of the classrooms (98%) lie in areas with a VMD of more than four.

School B:

The existence of the highly integrated, open courtyard enhanced visibility within the ground floor but not across different floors. Almost all classrooms (99%) are very isolated on the upper floors (VMD>4) especially the main cluster of classes on the first floor which are five turns from the entrance. The main vertical axis of circulation on the upper floor is very shallow. However, due to the upper floors arrangement on one side of the building, the right hand side learning spaces became more segregated. This effect was further amplified because the secondary horizontal axis was obstructed by an enclosed staircase which broke the continuity of the circulation.

School C:

Although the school has no major atrium that might enhance visibility across floors, VMD is in the middle ranking among the nine schools with no drastic variation across floors (second lowest standard deviation). This is achieved through a powerful circulation grid spreading across the plans and minimal labyrinthine areas. Unlike the previous two schools, there is only one axis of circulation as the most visible backbone of the school. Although the building appears to be symmetrical in its form, VSD shows that the shift of the entrance towards the left (with walls restricting visibility to the right hand side) resulted into overall shallower spaces on the left hand side from the entrance.

School D:

The building is ranked first in terms of visibility (lowest average VMD) with an even distribution, due to the powerful courtyard creating an extremely porous open ground floor plan. Unlike other schools (especially B and E, where the openness is gradually constrained across the upper floors), school D has four upper atria with a rectangular circulation grid. All classrooms and the socialising spaces (except the sports hall) lie in the areas with VSD less than three.

School E:

The building is considered middle ground between a closed environment (school F) and the other extreme of complete openness (school D). School E provides a design that features three middle courts showing as three atria on the first floor, but are then reduced to a single atrium on the other floors. In other words, the overall visibility is reduced gradually and the privacy starts to increase in terms of enclosures.

School F:

The design of school F is based on closed plans with no atria or visibility across floors (similar to C). In addition, the following reasons lead to the overall high VMD of the plans. Firstly, the circulation is highly controlled in terms of access points and limited connections between various zones. Secondly, the stripped floor plan is formed of elongated clusters resulting in a labyrinthine layout. Thirdly, the plans have short broken circulation corridors. This is portrayed in the VSD results where the art studios on the third floor are six, seven and eight steps away from the entrance.

School G:

This is the only one-storey school in the study. Its plan is divided into four main zones linked by a central circulation grid. VMD reveals the similarity in the values for three of the zones (average = 3.6, 3.7 and 3.8) except the fourth lower right zone which is deeper than the others (average = 4.5). The floor plan organisation dictates that one circulation artery is visually deeper in the whole system. The result is that the whole area linked through this corridor is visually separated from the rest of the school building.

School H:

VMD shows an even distribution of values within the central zone around the courtyard and atria in all of the floors (standard deviation = 0.56 for this specific area), the variation in the values of the VMD start to increase as spaces get further from the centre and deeper into the two wings (especially the right wing). Thus the standard deviation rises to 0.90 for the whole floor area including the two wings as well as the whole building which is the highest value among all the schools. In contrast to school G, where the location of the central entrance facilitated the visual connection to the rest of the plan, VSD shows that the main entrance of school H is situated in the furthest right end of the school causing an unbalance in the depth of many classrooms and socialising spaces from the entrance.

School I:

Although the school design has a courtyard, its VMD average is quite high (second highest in the sample). The building does not benefit from the visual connections a courtyard can provide. On the upper floors, the classrooms have small windows overlooking the courtyard. The ground floor seems to be divided into two zones: the triangular space with the courtyard and the lower rectangle. The two zones are connected using a horizontal axis of circulation, but there are only limited points of access between the two zones (three gateways). One of the gateways is relatively deeper than the others which results in amplified visual depth for the whole zone accessed through this gateway. Surprisingly, the VSD illustrates that the classrooms on the first and second floor are actually fewer than three steps away from the entrance, which is relatively shallow. While the performance of the courtyard and atria do not pay off, the vertical circulation (five staircases, one of which is open) caters for connections between the floors of the building.

5. PERFORMANCE EVALUATION OF THE SCHOOL BUILDINGS

To evaluate the spatial performance of the nine schools, VMD is used. In addition to the above provided metrics and visualisations, coloured histograms for the frequency (count) of 12 ranges of VMD values are compared (figure 4). This visualisation gives an idea of the distribution of values across the range and the distribution of areas within each range of depth. The more the values are shifted to the left (red) the higher the performance of the building in terms of visibility (low VMD), i.e. more integration and higher chances of students to meet, mix and socialise. School D is ranked first in terms of having the biggest portions of values in the integrated spectrum. Again, school F ranks lowest, as it lacks highly integrated spaces.

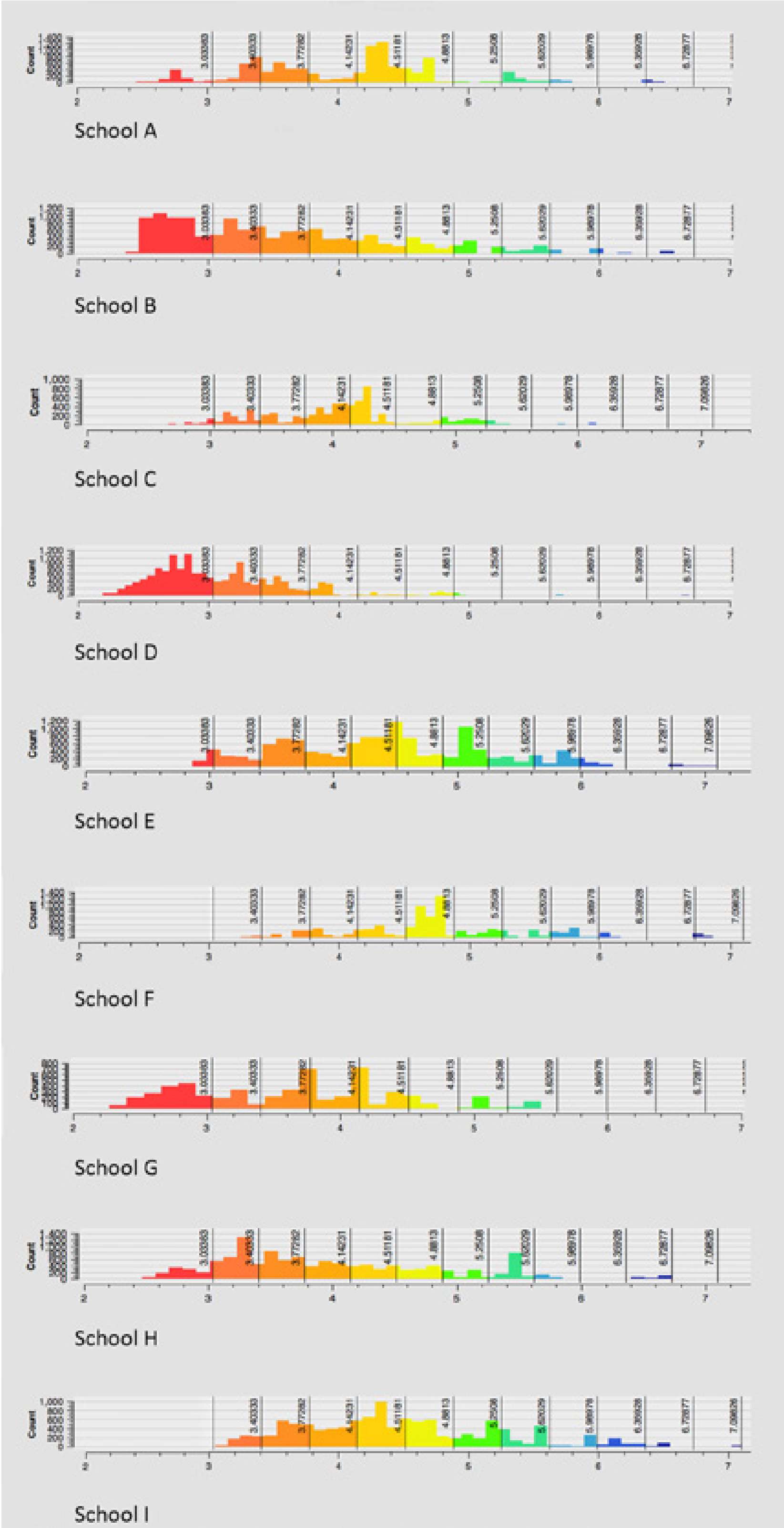


Figure 4 - Histograms of the Visual Mean Depth (VMD) Distribution.

A simplified way of assessment for the nine buildings and one way of testing the hypothesis that the spatial configuration has an effect on learning is plotting overall average VMD against the students' attainment results of each school (Figure 5). The students' attainment is obtained from governmental census datasets as well as the governmental online Ofsted reports (Ofsted, 2015) that provides evaluations of the schools in the UK. The value is the average of the attainment grades in the last four years (2012-2015) and the evaluation grade from the Ofsted report. The scoring system used means that lower values represent higher attainment. Schools I and E show the highest students' performance. Calculating the P-value and the R2 for the resulting chart shows a significant correlation (P-value=0.034) which is moderately strong (R2=-0.50). This proves that students' achievements relate to spatial configuration with higher performing schools being more spatially segregated as a whole. However, it is important to mention that it is not proven how the variation from one configuration to another (for example: from an open porous plan to a visually restricting closed zoning) would directly impact the students in terms of their academic achievement.

	A	B	C	D	E	F	G	H	I
Students' Attainment	3.27	1.92	2.17	3.12	0.96	1.49	3.37	1.76	0.92
Average Visual Mean Depth (VMD)	4.05	3.59	4.04	3.11	4.45	4.79	3.64	3.99	4.47

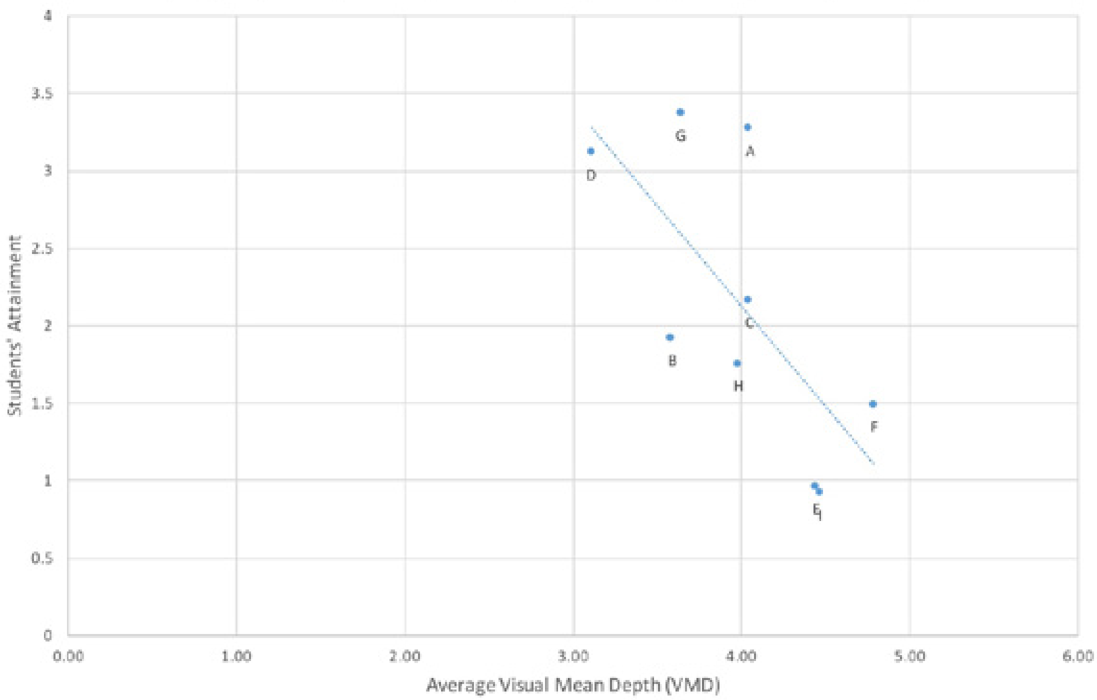
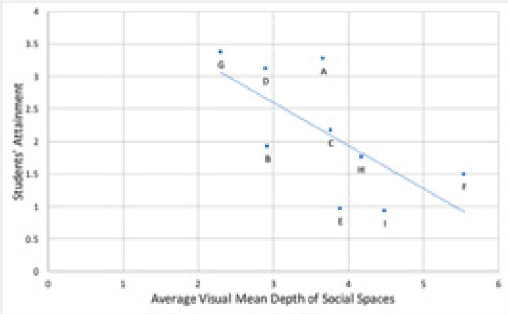


Figure 5 - Correlation Between the Students' Attainment and the Visual Mean Depth for the Nine Schools

A more specific way of testing the hypothesis of the effect of configuration on attainment is achieved by correlating the VMD values for specific areas with the students' attainment results. The rationale here is to investigate whether integrated or segregated classrooms, or integrated or segregated spaces for socialising have a particular effect on attainment. Figures 6a and b show the results of correlating the students' attainment against VMD of social spaces and classrooms respectively in each of the nine schools. Similar to the previous correlation, the results show a moderately strong correlation between attainment data and VMD of social spaces and classrooms (R2=-0.45 and -0.44 respectively).

	A	B	C	D	E	F	G	H	I
Students' Attainment	3.27	1.92	2.17	3.12	0.96	1.49	3.37	1.76	0.92
Average Visual Mean Depth of Social Spaces	3.67	2.93	3.77	2.91	3.9	5.54	2.31	4.18	4.49



	A	B	C	D	E	F	G	H	I
Students' Attainment	3.27	1.92	2.17	3.12	0.96	1.49	3.37	1.76	0.92
Average Visual Mean Depth of Classrooms	4.26	4.14	4.15	3.24	4.80	4.90	4.13	4.12	4.52

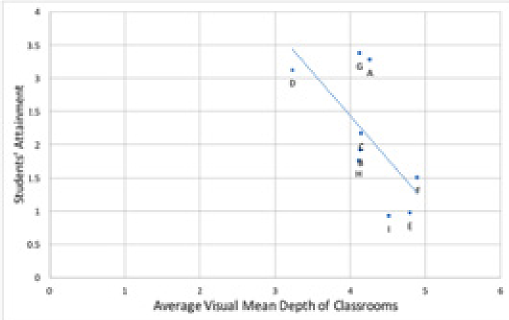


Figure 6 - a and b. Correlation between students' attainment and VMD of social spaces and classrooms

Again, a negative correlation is found, since schools with more segregated social spaces achieve better attainment results, and likewise, students in schools boasting more segregated classrooms are higher achievers.

6. THE LEARNING PROCESS: MORE THAN JUST ATTAINMENT

The previous section has highlighted a significant relation between the spatial configuration of the school buildings and the students' performance portrayed through their attainment results. Whilst it appears crucial to make use of the available quantitative analysis and data to prove the relation between space and learning, it should not be the final outcome of the research; because the learning process cannot be reduced to just attainment results of the students.

What is interesting in this respect is the strength of the correlation with average VMD for the school as a whole, where a higher correlation coefficient was achieved. It seems that the overall configuration of the school is more important than the structuring of social spaces and classrooms. If learning only happened in classrooms, we would expect to see a greater effect of segregated classrooms on attainment scores. The contrary is the case. This again brings in the idea of learning as a social process where every part of the student's life (including their interactions and behavioural experience) impacts the process of acquiring knowledge. The research continues with an attempt to understand more about the spatial potential that contributes to the affordance of the school building for social encounters and learning

7. AFFORDANCE OF THE SCHOOL BUILDING FOR SOCIAL ENCOUNTERS

The building as a whole (through its configuration) can be argued to function as the main facilitator for movements and social encounters. To an even greater extent, the designed social spaces should be able to fulfil their role as incubators for students' interactions. Figure 7 illustrates VMD of the schools' social spaces only. VMD values are highly dispersed across the spectrum (from 2.9 to 5.3). The spatial configuration of some schools (D, B, C and G) renders the main social spaces as estuaries where the primary or secondary axis of circulation pours into. In order to reach some areas of the plan, the students and staff will have to cross the social common space. Consequently, social spaces function as by-products of natural movement. If socialisation is proportional to the users' encounters, then this design layout (circulation intersecting the social spaces) would increase the potential of students' socialisation, as the social spaces become part of the students' through movement. It also increases the natural surveillance by staff on the students' gathering spaces. However, School E and F are the complete opposite, where social spaces do not overlap the circulation, which means that the potential for mixing their encounters is only reliant on the ability of theses spaces to act as attractors for the students (destinations). Moreover, the histograms illustrated in figure 7 show a discontinuity in the VMD values (shown as wide gaps) within certain ranges for the social spaces (example: school H).

This might reflect the lack of organisational design hierarchy between the social spaces; their dispersion across separate locations of varying VMD within the same building just to fulfil the space programme requirements of the school. Also, the graphs (figure 7) show that the larger and more open the social spaces are, the higher the concentration of the count in fewer bars at the left end of the spectrum (school B and E).

It could be argued then that in cases where the design of the circulation axis follows the general form/outline of the building, the resulting mean depth values are evenly distributed with less drastic changes across the floor plan (examples: School A and C). When one zone in the floor plan is attached to the other spaces through a single linkage, the visual segregation of the linking circulation results in amplified segregation of the internal spaces (example School G). Furthermore, it is crucial to mention that a courtyard design makes a major difference to the overall openness and visibility across the school building, yet the degree of its contribution is purely dependent on how other spaces are configured in relation to the courtyard which is solely a design decision. Other important spatial components like circulation; its form, its degree of hierarchy (branching) and the distribution of the staircases all subsidise the spatial performance of the school building.

In summary, it could be hypothesized that configuration exerts an influence on the ability of students to mix and encounter others. In schools structured like examples B, C, D and G we would expect to find a higher rate of encounters, whereas schools such as E and F would be more inhibitive of encounter and mixing.

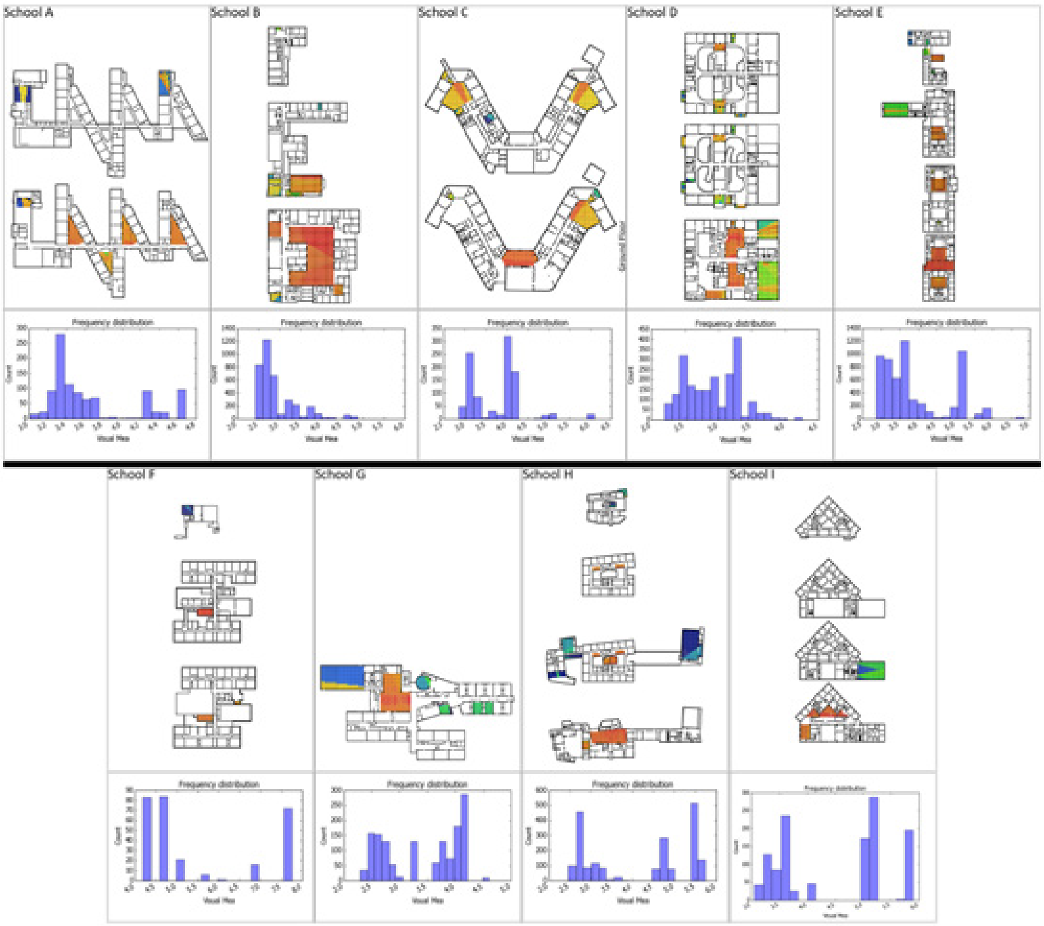


Figure 7 - VMD of social spaces only and including frequency distributions

8. AFFORDANCE OF THE SCHOOL BUILDING FOR LEARNING

Following the previous argument, learning inside the school building is assumed to take place across all spaces of a school. One question arising out of this is whether the available learning spaces in the shape of classrooms can or cannot afford the current learning processes, and what is the potential of space to accommodate other various learning formats. Analysis of the classrooms (figure 8) show their VMD values as highly condensed in the spectrum ranging from 4 or 5 turns (except school D with VMD=3.24) unlike the social spaces where VMD values for the nine schools were dispersed across the spectrum. Also, VMD of classrooms is higher than the average VMD of the whole school building (except for school I where the two values are almost equal). Based on the histograms it is proposed here that schools with a higher variation of VMD as expressed in a high spread of values across the histograms (no discontinuity in the graph) have more variety of learning spaces in terms of depth which increases the potential of the spaces to afford various learning formats (ranging from active busy integrated spaces to quiet segregated spaces for high concentration).

Schools A, F and G have a low number of separate bars in the histograms and their floor plans are characterised by equally deep monotonous learning spaces forming 32%, 39% and 29% of the total classroom area, i.e. low potential to afford various learning formats (table 2). If learning is prevailed through an open interactive environment and through different formats (not just the traditional closed classroom), then students' understanding and comprehension is expected to be higher within buildings with the potential to accommodate/afford different learning formats and provide various levels of spatial privacy, porosity and visual connectivity.

In summary, it could be hypothesized that schools with more varied VMD values for classrooms would also afford more different learning formats.

	A	B	C	D	E	F	G	H	I
Number of filled histograms	13	16	14	15	12	9	11	13	15
Highest concentration in one histogram	1400	500	800	700	2400	1300	500	580	1080
Total of all histograms	4439	4314	2836	4445	8518	3330	1746	3906	4890
% concentration out of the total area (Monotony in the VMD)	32%	12%	28%	16%	28%	39%	29%	15%	22%
Ranking according to affordance of various learning formats (variation in the VMD)	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
	B	H	D	I	C	E	G	A	F

Table 2 - Affordance of the Nine School Buildings to Accommodate Different Learning Formats

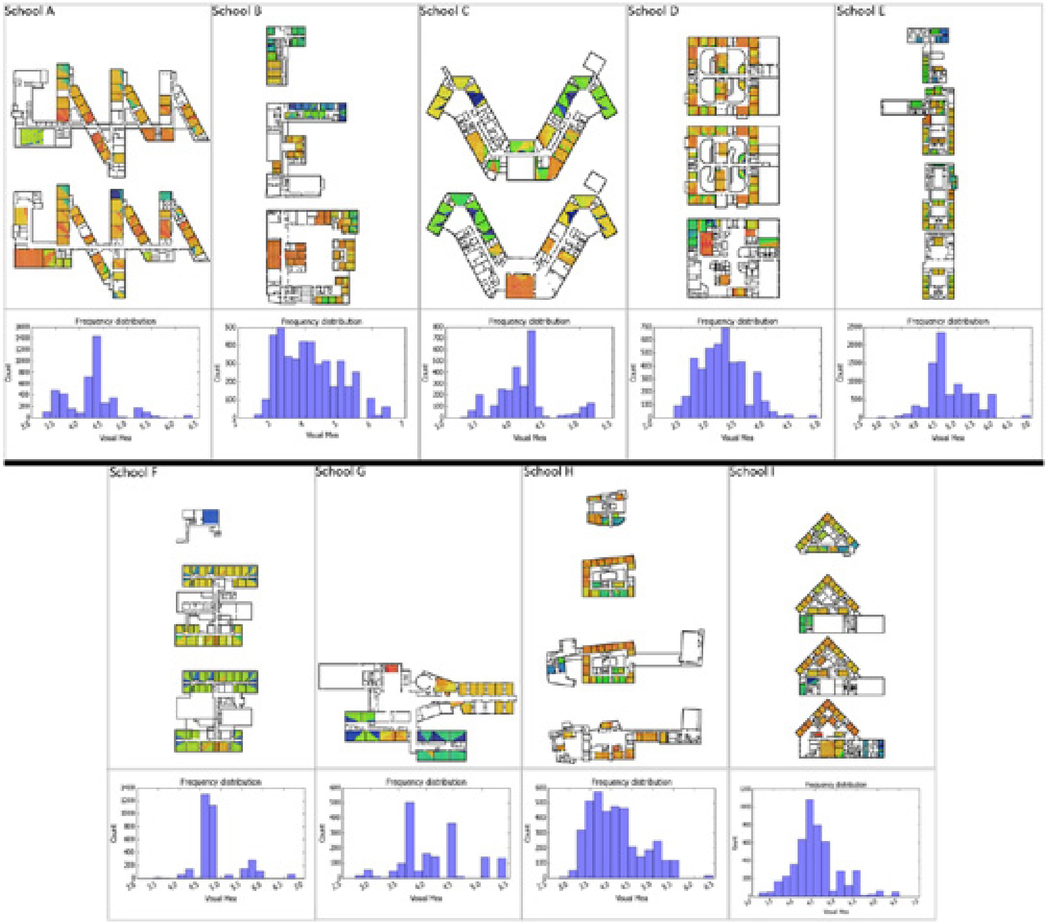


Figure 8 - VMD of classrooms only and including frequency distributions

9. DISCUSSION AND DESIGN IMPLICATIONS

The findings of this research can be divided into two main sets of results which both have utilised spatial syntactic analysis to explain the relation between space and learning inside schools. The first combined quantitative data (students' attainment for the nine schools) with syntactic metrics to prove the hypothesis that spatial configuration impacts learning outcomes. More segregated schools were found to show better outcomes. This is in line with findings from previous research, where highly integrated schools were reported by teachers as less suitable in supporting varying teaching styles (Kishimoto and Taguchi, 2014).

Since attainment figures do not fully describe learning and socialising inside the school building, the second set of results established foundations for the relation between space, socialising and learning through exploring the spatial potential of the building to afford, facilitate and trigger students' social activities and learning.

Regarding socialising, it was proposed that building form and configuration, i.e. the way functional elements are connected could affect socialisation patterns. This builds upon previous research which highlighted that compact buildings showed different encounter patterns from finger layouts (Pasalar, 2003). Here it is argued that the exact interplay and connections of functional elements needs to be taken into account in a more detailed way.

Regarding learning processes, it was argued that a higher variation of syntactic values for classrooms could better support a variety of learning formats. Extreme ends of the spectrum (very integrated and shallow vs very segregated and deep) are neither supportive nor inhibitive for the learning process, because it depends on what format of learning is being implemented.

The analysis showed that some of the learning spaces (assigned with specific functions of lectures, seminars, discussion, etc.) were concentrated on the upper floors, yet often without any direct links to social areas. Rather than assigning classrooms segregated spaces by default only accessed through narrow corridors, their location could instead be derived from the spatial need of the learning process. If learning is considered "a social process where new insights are actively constructed in the mind of a learner through a mix of activities and processes" (Sailer, 2015, P.15), and if the school is interested in implementing a weakly framed learning methodology with more freedom granted to the learner (Bernstein, 1973), then openness, connectivity and flexibility are appropriate spatial criteria to implement. Yet, if privacy and isolation are favoured for another learning format, then the upper more segregated floors might be more suitable. The main point is that the allocation during the design process might not be based on the normal top-down zoning process (which is based on area fulfilment and checklists). The design of the school building could instead respond to the needs of the learning process and the school vision in order to facilitate the learning process set by the management.

This research has been able to explore these issues and propose hypothesis to be tested, however the actual relation between spatial characteristics of classrooms and suitability for different learning processes and formats are yet to be more fully established in a rigorous empirical study.

10. CONCLUSION

In this paper, learning was re-conceptualised as a social process mainly dependent on the perceptions, interactions and the comprehension of knowledge by the learner where the learning context (the built environment) is not just the background but actually impacts the process. Space was argued to have an impact on learning outcomes since it was shown that spatial configuration impacts students' attainment with more segregated schools showing better student performance. The research also explored the spatial potential and affordance of school buildings for social encounters and more varied learning processes beyond attainment scores. Hypotheses were formulated that could be tested against empirical data in further research.

Limitations of this study include the rather small sample size for statistical analysis and a lack of observational and behavioural data which could be addressed in further research. The Built environment is one factor of many impacting on student learning outcomes. Thus, extrapolation of any conclusion from the results of this research should be carefully considered and should be supported by further research that covers other physical resources, learners, learning leadership, and school policies. The future studies could include specific non-spatial parameters such as social deprivation of schools, school management and quality of teaching alongside variables of spatial configuration in a more complex multivariate model. The ultimate contribution would be to provide guidelines that might assist architects during the design process, in order to create buildings that are optimised to accommodate functional programmes and new modes of teaching and learning.

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