Walkability as an indicator of informal creative spaces within higher education campuses

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Abstract: This paper argues that among all other spaces, pedestrian streets in a university campus also serve as "informal creative spaces", where people meet each other while walking, crossing or simply standing and talking to each other. The study proposes a three-level approach to assess the street scapes of university campuses. First, a walkability audit of the pedestrian streets (sampled sequence) of higher education campuses, using a modified version of the well-established walkability audit tool developed by the Centre for Disease Control, U.S.A. Second, collecting students' responses on the same influencing factors as used in the audit tool and questionnaire. Third, a topological analysis of the pedestrian streets using space syntax. Finally, a correlation study of the outcomes will be done to understand the factors of walkability relevant to higher education campuses. The syntactic analysis data further backs the findings theoretically.

This methodology ensures the importance of pedestrian streets as an 'informal meeting space' within higher education campuses by relating walkability to social interaction and creative exchange in higher education campuses. Increased social interaction and liveliness through increasing walkability of pedestrian streets within higher education campuses, and establishing the role of mobility networks in overall campus creativity. The outcomes of the study can be useful for architects and planners to convince the management and decision makers to invest in building and developing pedestrian networks and facilities.

***IndexTerms* - Higher education campuses, Mobility networks, Open Spaces, Pedestrians, Space Syntax, Creativity, Walkability**

I. INTRODUCTION

Higher education campuses are considered a powerhouse of creativity as they are fostering exchange between students, scholars, entrepreneurs, activists and many other creative members of the public. Campuses vary in scale, size and planning typologies but have practically similar kind of spaces and voids, in general. Thus, problems and issues are more often seems to be typical and comparable in nature with varying level of severity (M.Z. Abd-Razak et al., 2011). The intense level of activities happening within these campuses and its vicinity, supposed to create a more creative, conducive and interactive community environment, but with that it also generates problems like stress (Andersson et al., 2009; Chambel and Curral, 2005; Misra and Mckean, 2000; Mosley et al., 1994). Mobility networks within the campuses, specifically pedestrian streets and open spaces are generally planned to amplify the productivity, efficiency and relieve stress, among university members. Many institutes of higher education across the globe are adding specific indoor and outdoor spaces to their facilities in order to accommodate an increasing demand for people to meet, discuss ideas, share knowledge and learn in a collaborative way.

However, the role of mobility networks as an 'informal meeting space' in higher education campuses to promote creativity has been rarely discussed anywhere and ignored by urban design research. Whenever, one meet other person while walking on campus streets or walk in a group to certain destination, use to talk, shake hand, exchange and share ideas. On the contrary, the campus design and research community less emphasize on this characteristic property of the campus streets. Designing streets and pedestrian's infrastructure considering them as a place for exchanging ideas and talks, will results in increased creativity and productivity level of the higher education campuses.

The positive effects of increased social interaction and liveliness in open spaces have been shown elsewhere (Florida, 2002; Winden; Mehta, 2006), including more meaningful exchange of ideas, learnings and understandings, increased physical activity and stress relieve. Much research had already been done, which relates liveliness and creativeness in physical environments (Nov and Jones, 2003; Smith and Shalley, 2003; Jen 2014; Montuori).

This study will frame the typical indicative issues of pedestrian streets within higher education campuses that will lead to liveliness and what factors hinder students to use them as places to meet, hang-out or spend leisure and recreational time at environmental level and psychological level.

This study investigated the walkability of two higher education campuses and will try to relate it with its inclusivity value.

II. LITERATURE REVIEW

2.1 What is walkability?

Walkability is a little difficult to define and measure. A wide range of definitions for walkability have been presented in the literature (e.g. Park, 2008; Alberta Association Canadian Institute of Planners, 2010; Southworth, 2005), however, we have chosen an adaptation to Southworth's (2005) definition to describe it:

> "Walkability is the extent to which the built environment supports and encourages walking and cycling by providing for pedestrian and cyclist comfort and safety, connecting people with varied destinations within a reasonable amount of time and effort, and offering visual interest in journeys throughout the network".

For the purpose of this research, we have excluded bikeability from the concept of walkability.

2.2 Importance of walkability?

In addition to its significant contribution like sustainability, healthy living habits, economic and environmental benefits (Park, 2008; Leyden, 2003; Newmen and Kenworthy, 1999), to the environment, walkability also contribute social interaction and creative exchange of ideas and thoughts within higher education campuses.

Walkability has also been shown directly related with obesity and sedentary lifestyles (Roberts et al., 2012; Keating et al., 2005; Cochrane and Davey, 2008; Owen, Leslie, 2000). Moreover, communities with high walkability rating have been associated with increased physical activity and lower body weights (Renalds, 2010).

Streets as a place for social places for meeting, shopping, leisure has been discussed by many researchers (Stobart, 1998; Chase. W, 2010). The relationship between lively streets: built environment and social behaviour has been also discussed elsewhere (Mehta. V, 2006). Public spaces facilitates the exchange of ideas, friendships, goods and skills. At their best, streets within university campus act like a self-organising public meeting and gathering services. A shared resources to improve people's quality of life, social spaces from a shared open spatial resource from which experiences and value are created in ways that are not possible in indoor environment (Mean et al., 2005).

2.3 Campus walkability?

Higher education campuses present an unique opportunity for evaluating walkability and understanding its relationship with social interaction and creative idea exchanges, as they supports a significant large population with a comparatively small region, and are composed of a number of facilities distributed across this region and at the same time has high pedestrian volume.

2.4 Evaluating walkability?

There are many factors that effects the walkability of an environment, including the complexity of the path networks, presence of buffers, presence of shade, sidewalk amenities, street scale, etc. (Jaskiewicz, 2000; Park, 2008). Quantifying the concept of walkability is rather difficult task as its perception vary across the world with different cultural, social and behavioural diversity and its perception may in many cases be subjective. Many attempts were done in order to quantify walkability of an environment, starting from the early 1990's (1000 Friends of Oregon, 1993) where the PEF: Pedestrian Environmental Factor was developed. Extending the work, several more investigation were attempted (Saelens et. al, 2003; Dixon, 1996, Landis et al., 2006; Boarnet et al. , 2006; Day et al., 2006).

A variety of audit tools have been developed afterwards, and used in walkability studies (e.g. Clifton et al., 2007). There are approximately 15 walkability audit tools, currently used in current world. To name a few, PEDS-2007 (Pedestrian Environment Data Scan), SPACES-2002 (Systematic Pedestrian and Cycling Environmental Scan), Walkscore-2014, Walkability Audit tool(Centre for Disease control, U.S.A), etc. Furthermore, time-to-time these audit tools are modified and developed to suit the requirements of the study, e.g. Post-secondary semantics walkability audit tool developed from CDC, walkability audit tool

These audits are generally easy to use and practical, and have also demonstrated high reliability (e.g. Pikora et al., 2002; Clifton, 2007), which make them useful in identifying barriers to walkability in an urban setup, and addressing them in order to improve accessibility and integration resulting in better social and interactive environment.

2.5Space syntax research?

Space syntax provides a set of quantitative indices for characterizing spaces in ways that would be relevant to research a variety of psychological responses. This would include peoples' perception of spaciousness, stress and fear through isovist properties (Montello, 2007). A recent research tries to establish the relation between stress level perceptions of user in an open public space and its spatial characteristics (Knöll, Martin; Li, Yang; Neuheuser, Katrin; Rudolph-cleff, Annette; 2015). There are some other researchers also, who established the relationship between spatial configuration of a space and physical & behavioural characteristics of human in terms of interestingness, activeness, stress, beauty, etc. (Benedikt, 1979; Franz & Wiener, 2008; Batty, 2001; Osmond, 2011) through linking users' data to isovist properties of the space.

Similarly, some researches applied space syntax theory and tools to analyse the accessibility of space and street through visual & convex and axial analysis (Hanson & Hiller 1984, 2004; Heitor T. et al.,2013; Kawatolski, Heitor, T, et al). Linked the universal design principle to space syntax tool through axial analysis and VG Analysis, HH integration (HH- Hanson and Hiller).

Very few research also relate space syntax tools to walkability index of commercial spaces and environmental perception (Özer O. et al; Long L. et al.; Choi E. et al.). Higher education campuses having different land use mix are never been explored in space syntax researches. Similarly, the subjective environmental qualities which affect the interaction level of a neighbourhood also not been explored much and not be seen together with street walkability.

III. RESEARCH QUESTIONS

Is walkability a suitable indicator for social interaction and a measure of creativity in university campuses?

IV. RESEARCH METHODOLOGY

4.1 Study Area

The Study were conducted on the two campuses of Technische Universität Darmstadt; Stadtmitte and Lichtwiese Campus. The selection were based on its status of Higher Education University or Institution (Premium or Institution of National Importance) and the convenience of the author.

4.2Target group

Target group of this study were students of both campuses as they are the sole and largest population share. Secondly, they are the ones who walks to commute within the campus. 3 expert auditor, with architectural and urban planning background having good understanding walkability were selected for auditing. In addition, agroup of 15 student volunteer members, from varying ethnicity and cultural background were selected to perform walkability audit in order to minimise the biasedness. They were also inducted, before performing the audit.

4.3Data types, Sources and Collection tools

Quantitative data will be collected through walkability audit.

Table 1: Data types, Sources and Collection tools

Data Type	Tool	Purpose(s)	Required aids	Remarks
Quantitative	Walkability Audit: On site(Expert Audit-3, Volunteer Audit- 15)	To assess the walkability of mobility networks by expert auditors (3 expert auditors)	Online database + audit tools	Audit tool is a modified version of the CDC's walkability tool.

	Space Syntax Analysis	To assess the campus topologically/ syntactically.	Digital drawing file (.dxf) of campuses, MS Excel 2013	To get Integration data (numeric) value of street segments.

4.4 Experimental Audit tool (Developed from CDC's Walkability tool)

Walkability has been defined as an intangible concept and its conceptual definition limits it accurate and concrete measurement. In order to conduct empirical research, walkability needs to be quantified into more tangible and measurable components. These components were used as proxies to objectify the walkability to address research questions (Park, 2008).

The important indicators to consider are environmental and the perceptions and behaviours of pedestrians. However, due to limited of this research study, we chose to focus on environmental component of walkability. Through literature study, we chose to further modify CDC's walkability audit tool (from Postsecondary education campus walkability semantic differential assessment instrument; Horacek et al. 2012) by adding one more parameter i.e. *cleanliness*. A handy/mobile walkability audit tool with an online database was developed and the data were collected. The collected data was stored into a 'Microsoft Excel' format and was analysed to determine the walkability score with the defined formula of weighted mean. The audit suggests using assessments of 3 expert auditors and 14 volunteer auditors.

The major characteristics the audit tool assesses include: safety, path quality, and path temperature comfort. The component of the *safety* subscale include pedestrian facility, crosswalk quality, pedestrian-vehicle conflicts, and night-time usages and safety. Pedestrian facilities investigate about the sidewalks presence and its location with reference the road. Crosswalk quality examines if a crosswalk is located at an intersection with appropriate walk signals and traffic control indicators, such as stop sign, zebra crossing, etc. Pedestrian/motor vehicle conflicts takes account of the traffic volume and examine the potential of conflict between them. Night-time safety feature accounts for emergency call boxes and other night features which would aid in the safety of the pedestrians. The component of the *path quality* subscale include path maintenance, path size, buffer zone, accessibility for mobility impaired, terrains and aesthetics. Path maintenance examines the presence of tripping hazards and overall maintenance. Path size assess the width of path. Buffer zone considers the space between the pedestrian path and the road. Accessibility for mobility impaired consist of the features which would allow access for the person with mobility impairment. Terrain measures examines whether or not a path is easily walkable, walking surface are smooth and flat or it requires some effort to walk on. Aesthetics considers whether the view or the visual perception of the path is pleasing to eyes or not. Shade is the criteria for the path temperature. Shade provides protection from the sun's heat, lowers temperature, protects from shower and allow a slightly favourable conditions to walk.

Each item was scored on a Likert's scale of 1 to 5. Guidelines set for scoring are mentioned below. A score of 1 is an indicator, that a path segment does not support a particular walking feature and may be dangerous to pedestrians. A score of 5 indicates that a path segment is most supportive of that particular walking and is safe for pedestrians.

Weightage given to high priority sub-score is 3.

High Priority Sub-score = (Pedestrian facilities + P-V conflicts + Crosswalk quality + Accessibility for mobility impaired) X 3

Weightage given to medium priority sub-score is 2.

Medium Priority Sub- Score= (Maintenance + path size + Buffer + Bikieability + Terrain + Aesthetic + Cleanliness + Shade) X 2

Overall walkability score= Average of high and medium priority sub-score of all walkability components.

4.5Sampling of street sequences

A street sequence per campus had been chosen for the audit, based on certain well defined criteria (refer appendix A.1) evolved from the observational study of students' movement pattern within higher education campus. Finally, the whole street sequence is divided into 5 segments and their individual walkability score is determined. The overall walkability score of the campus is assumed to be the simple average of all the segments.

4.6 Proceedings

A walkability audit of the selected street sequences was done, first by three expert auditor with architectural and transportation expertise followed by a group of 15 student volunteer belonging from different cultural and academic background with a little induction. Later, a comparison was done to check the inter-reliability of auditors.

In parallel, space syntax axial analysis was performed using *Depthmap X* application software. The value of HH (Hillier and Hanson)–integration at radius R-1200 of the selected street sequence was taken-out and compared with walkability score of those street segment. To understand the trend of integration values the street segment is divided further into more fractions.

Finally, a correlation study was done between the average walkability score of each segments and the HH-integration value (R1200). If the correlation coefficient is greater than 0.75 with a value of confidence interval of 95%, advocate that, there is a strong relationship between walkability and street integration, which further prove its strong relation with social interaction and creative idea exchange.

4.7Scope and limitation

1. The study focus on higher education campuses only.
2. It is first hand explorative study and based on data gained from two higher education campuses only.
3. Walkability is done only on the sampled street sequence, which is assumed to be the representative of the whole campus. All the street of the campus is not audited.

IV. RESULTS

The individual scores of 13 individual components of walkability for Stadtmitte and Lichtwiese campus at TU Darmstadt are detailed under the following tables.

Table 2: Walkability Score of Stadtmitte Campus, TU Darmstadt

Factors	Segment 1		Segment 2		Segment 3		Segment 4		Segment 5		Campus
	Exp. (3)	Vol. (14)	Exp. (3)	Vol. (14)	Exp. (3)	Vol. (14)	Exp. (3)	Vol. (14)	Exp.(3)	Vol. (14)	
Pedestrian Facilities (H)	4.0	4.9	4.0	4.5	5.0	5.0	5.0	5.0	5.0	5.0	4.7
P-V conflicts (H)	4.3	4.5	4.7	4.1	5.0	5.0	5.0	4.3	4.0	3.9	4.5
Crosswalk quality (H)	5.0	4.8	4.0	4.7	5.0	5.0	5.0	5.0	5.0	5.0	4.8
Night-time safety (M)	4.0	3.1	4.0	3.6	5.0	4.3	4.0	4.0	4.7	4.2	4.1
Maintenance (M)	4.3	4.2	4.0	4.1	4.7	4.3	4.0	4.0	4.0	4.0	4.2
Path Size (M)	4.7	4.9	4.7	4.8	5.0	5.0	5.0	5.0	4.7	4.9	4.9
Buffer (M)	3.7	4.6	3.7	3.8	5.0	5.0	5.0	5.0	4.3	4.1	4.4
Accessibility (H)	4.7	4.6	4.0	4.0	4.3	4.2	5.0	4.5	3.7	3.5	4.2
Bikeability (M)	4.0	4.0	3.7	3.9	4.0	4.0	4.7	4.1	4.0	4.0	4.0

Terrain (M)	4.7	4.6	4.0	4.1	5.0	5.0	5.0	4.1	4.0	4.0	4.4
Aesthetics (M)	4.7	4.9	3.7	3.7	4.7	4.1	4.3	4.1	4.0	3.7	4.2
Cleanliness (M)	4.3	4.1	4.3	4.1	4.0	4.3	4.3	4.1	3.7	3.8	4.1
Shade (M)	4.3	4.1	3.7	3.1	2.7	2.8	3.7	3.5	3.0	3.0	3.4
High Importance	18.0	18.7	16.7	17.3	19.3	19.2	20.0	18.8	17.7	17.4	18.3
Medium Importance	38.6	38.5	35.6	35.2	40.0	38.7	40.0	37.8	36.3	35.7	37.6
Total Score	131.2	133.1	121.3	122.4	138.0	135.1	140.0	132.0	125.6	123.6	**130.2**
Segment Walkability	87.49	88.74	80.84	81.59	91.97	90.04	93.31	87.99	83.73	82.43	**86.81**
Expert:	**87.47**			**Volunteers**	**86.16**						
Overall Walkability	**86.81**										**86.81**

Table 3: Walkability Score of Lichtwiese Campus, TU Darmstadt

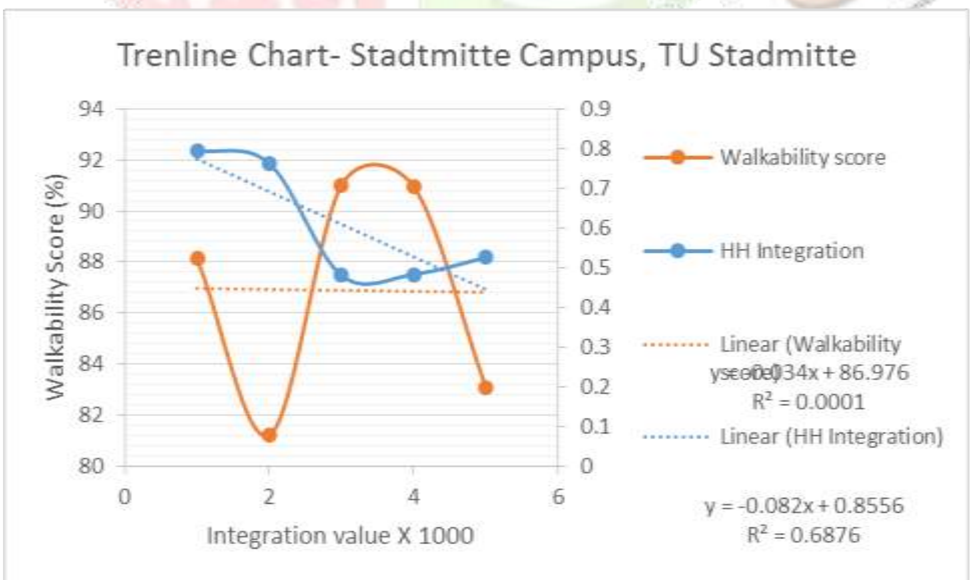
	Segment 1		Segment 2		Segment 3		Segment 4		Segment 5		Campus
Factors	Exp. (3)	Vol. (14)	Exp. (3)	Vol. (14)	Exp. (3)	Vol. (14)	Exp. (3)	Vol. (14)	Exp. (3)	Vol. (14)	
Pedestrian Facilities (H)	4.3	4.0	3.7	4.3	5	5	4.3	4.0	4.3	4.1	4.3
P-V conflicts (H)	4.3	4.7	5	5	5	5	4	4.1	4.7	5.0	4.7
Crosswalk quality (H)	4.3	5.0	5	5	5	5	4.3	4.4	5.0	5.0	4.8
Night-time safety (M)	3.3	3.4	4.0	4.0	4.7	4.9	4.0	3.7	2.3	2.1	3.6
Maintenance (M)	3.3	3.6	4.0	3.3	4.7	5.0	4.3	4.1	3.3	4.0	4.0
Path Size (M)	4.7	4.9	4.7	4.9	5.0	5.0	4.7	4.9	4.7	4.9	4.8
Buffer (M)	4.7	4.6	5.0	5.0	5.0	5.0	4.3	4.1	4.7	4.7	4.7
Accessibility (H)	3.0	3.3	3.3	3.9	4.7	5.0	4.3	4.3	4.0	4.0	4.0
Bikeability (M)	4.0	3.9	3.3	3.9	4.0	4.0	4.0	4.1	4.0	4.0	3.9
Terrain (M)	4.0	4.0	4.0	4.0	5.0	5.0	4.3	4.6	4.0	4.4	4.3
Aesthetics (M)	4.7	4.6	3.7	3.0	4.0	4.0	3.7	3.1	3.7	4.0	3.8
Cleanliness (M)	3.3	3.0	3.0	3.0	4.0	4.6	4.0	3.9	3.7	3.7	3.6
Shade (M)	4.0	4.1	3.0	3.0	3.0	3.0	3.3	3.1	4.0	3.9	3.4
High Importance	15.9	17.0	17.0	18.2	19.7	20.0	16.9	16.8	18.0	18.1	17.8

Medium Importance	36.0	36.0	34.7	34.0	39.3	40.4	36.6	35.7	34.3	35.7	36.3
Total Score	119.6	122.8	120.4	122.4	137.6	140.8	124.1	121.7	122.6	125.6	**125.8**
Segment Walkability	79.76	81.89	80.26	81.61	91.75	93.89	82.71	81.13	81.73	83.75	**83.85**
Expert:	**83.24**			**Vol.**	**84.45**						
Overall Walkability	**83.85**										**83.85**

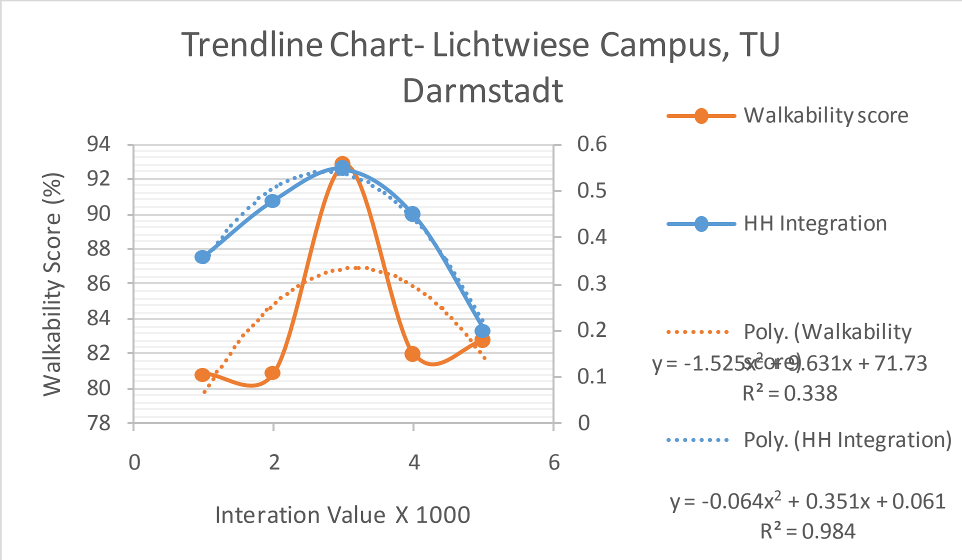
Table 4: Comparison between HH-Integration values and Walkability score of individual segments

Segment	Average Integration Value (R 1200) SM, TU D	Walkability Score	Average Integration Value (R 1200) LW, TU D	Walkability Score
Segment 1	0.796	88.12	0.3595	80.83
Segment 2	0.7625	81.21	0.4801	80.93
Segment 3	0.4804	91.01	0.5466	92.82
Segment 4	0.4832	90.95	0.4479	81.92
Segment 5	0.5255	83.08	0.2007	82.74

Note: See Appendix A2 for HH-integration map.



Correlation Coefficient: -0.4823



Correlation Coefficient: 0.4914

V. Discussion

This study found that almost every street of both the campuses of the TU Darmstadt, are pretty much walkable, having a walkability score more than 80. Stadtmitte campus has a walkability score of 86.81/100 and Lichtwiese campus has 83.35/100. Further, the walkability score follow a random distribution in both campuses and showed as bell-shaped curve. In contrast, the values of HH-integration values at R1200 (generated with *Depthmap X application software)*, showed variation in the two campuses. The variation is supposed to be caused by the location of respective campuses in the wider street network of the city. Since, the Stadtmitte campus is located at the city centre and is highly integrated with city spaces as compared to the Lichtwiese campus, which is located at the periphery of the city and slightly less integrated to the city. Due to high integration with the surrounding, Stadtmitte campus has high HH-integration value at its periphery.

However, the correlation between the walkability score and HH integration (R1200) values of the 5 five segments (selected street sequence) is approximately 0.5 (moderately correlated) , which is not sufficient to establish any relation between them.

In general, the integration value of the starts with comparatively lower value at the periphery and increases slightly up at the central zone and further end with relatively lower value at the periphery. Streets and zones with higher HH-integration value (R1200) suggests high integration and connection with respect to the rest of the campus and supposed to have high foot fall and pedestrians. High volume of pedestrian having similar academic background, interests, and familiarity increases the potential of social interaction and creative exchange. Increasing the walkability a step more, by introducing the lacking pedestrian facilities, will certainly increase the social interaction level. Thus, results in higher creative environment.

VI. Conclusions

This study has assessed the walkability of mobility networks of the two campuses of TU Darmstadt, i.e. Stadtmitte and Lichtwiese campus in order to relate walkability as an indicator on informal creative space within the higher education campuses. A sampled street sequence, one from each campus is audited by 3 expert auditors and 14 student volunteers and then compared with HH-integration (R1200) of the axial analysis of the respective campus. The analysis shows 0.5 correlation between both the data and suggest moderate correlation. However, the study was done on only two campuses and was explorative in nature. Deducing any strong conclusions at this moment is not suggested and reliable. More in-depth study with inclusion of different campus typologies are needed to get any sound result.

REFERENCES

[1] 1000 Friends of Oregon (1993). Making the land use transportation air quality connection: The pedestrian Environment – Volume 4A: Parsons Brinckerhof Quade and Douglas, Inc. Retrived from: http://ntl.bts.gov/docs/tped.html

[2]Andersson,C.,Johnsson,K.O.,Burgland,M.,Ojehgen,A.,2009. Stress and hazardous alcoholuse: associations with early drop - out from university. Scand. J. Public Health 37,713–719.

[3]Abd-Razak, M.Z., Goh Abdullah, N.A., Mohd Nor, M.F. I., Usman, I.M. S., & Che-Ani, A.I. (2011). Toward a Sustainable Campus: Comparison of the Physical Development Planning of Research University Campuses in Malaysia. Journal of Sustainable Development, 4(4). doi: 10.5539/jsd.v4n4p210.

[4]Centres for Disease Control and Prevention. (2010). Walkability Audit Tool. U.S Department of Health and Human Services. Retrieved from: http://www.cdc.gov.in/nccdphp/dnpao/hwi/toolkits/walkability/ audit_tool.htm

[5]Chambel, M. J. and Curral, L. (2005), Stress in Academic Life: Work Characteristics as Predictors of Student Well-being and Performance. Applied Psychology: An International Review, 54: 135–147. doi: 10.1111/j.1464-0597.2005.00200.x

[6]Chida, Y.,Hamer, M.,2008.Chronicpsychologicalfactorsandcute physiological responses laboratory-induced stress in healthy populations:aquantitativereviewof30yearsofinvestigations. Psychol. Bull.134, 829–885.

[7]Christian, S.C., Cochrane, S.C., Creelman, M.C., Apollonia, L, A., Geoff, G.T., & Wiggings, M.W., (2010). Studley campus walkability assessment. Informally published manuscript, Department of Environment Science, Dalhousie University, Halifax Canada.

[8]Eckerling,M.,(1996).Guidelinesfordesigninghealinggardens.J. Ther.Hortic.8, 21–25

[9]Florida, R. (2002). The rise of the creative class, and how it's transforming work, leisure, community and everyday life, New York, Basic Books.

[10]Heitor, T., Nascimento, R., Tomé, A., & Medeiros, V. (2013). (IN)ACCESSIBLE CAMPUS: Space syntax for universal designer Space. Space Syntax Symposium 2013. Retrieved September 6, 2015, from http://www.sss9.or.kr/paperpdf/scb/SSS9_2013_REF084_P.pdf

[11]Horacek, T.M.H., White, A.A.W., Greene, G.W.G., Reznar, M.M.R., Quick, V.M.Q., Morrell, J.S.M., Colby, S.M.C., & Kattelmann, K.K.K., (2012). An assessment of the walkability and bikieability of U.S postsecondary institutions. *Sneakers and Spokes*, 24(7):8-15. Retrieved from: http://web.b.ebschohost/ehost.pdfviewer/pdfviewer?sid=e07514ec-354e-4e35828-0f546ad0c627@sessionmgr118&vid=4&hid=555

[12]Jaskiewicz, F.(2000). Pedestrian level of service based on trip quality In *Transportation Research Broad Circular. E-C019: Urban Street Symposium*. Retrieved from: http://www.urbanstreet.info/2nd_sym_proceedings/Volume%201/Ec019_g1.pdf

[13]Jen, C.T., (2014). Social Ties, Knowledge Diversity and Individual creativity, *National Defence University, Taiwan (ROC)*. Retrieved from: http://jbsq.org/wp-content/uploads/2014/12/December_2014_8.pdf

[14]Kanvinde, A., & Miller, H. (1969). Campus design in India; experience of a developing nation. Topeka, Kan.: Printed by Jostens/American Yearbook

[15]Keating, X.C., Guan, J., Pinero, J.C., and Bridges, D.M., (2005). A meta-analysis of college students' physical activity behaviours. *Journal of American College Health, 54(2): 116-125*

[16]Knoell, M., Li, Yang, Neuheuser, K., Rudolph-Cleff, A., (2015). Using space syntax to analyse stress ratings of open public spaces. Proceedings of the 10th International Space Syntax Symposium, 123:1, 247-259. Retrieved September 11, 2015, from www.sss10.bartlett.ucl.ac.uk/wp-content/.../SSS10_Proceedings_123.pdf

[17]Lau, S., Gou, Z., & Liu, Y. (2014). Healthy campus by open space design: Approaches and guidelines. Frontiers of Architectural Research, 3(4), 452-467. Retrieved August 30, 2015, from http://www.sciencedirect.com/science/article/pii/S2095263514000430/pdfft?md5=5be1193c842e9b3b2c96b2504bde9d12&pid=1-s2.0-S2095263514000430-main.pdfarney, J.B., (1991) "Firm Resources and Sustained Competitive Advantage", Journal of Management, Vol. 17, No. 1, pp. 99-120.

[18]Leyden, K. (2003). Social Capital and Built environment: The Importance of Walkable neighbourhoods. *Am. J. Public Health, 93(9): 1546-1403*

[19]Mehta, V., (2006). Lively streets: Exploring the relationship between built environment and social behaviour; Phd. Dissertation; Urban and regional planning and Design. Retrieved from: http://drum.lib.umd.edu/bitstream/handle/1903/4165/umi-umd-3962.pdf?sequence=1&isAllowed=y

[20]Misra, R., McKean, M., (2000). College students' academic stress and its relation to their anxiety, time management, and Leisure satisfaction; *American Journal of Health Studies, Vol. 16; Issue 1*, pg. 41. Retrived from: http://connection.ebscohost.com/c/articles/3308416/college-students-academic-stress-relation-their-anxiety-time-management-leisure-satisfaction

[21]Mountuori, A., Creativity: Social Psychology, Retrieved from: http://www.academia.edu/1067767/Creativity_Social_Psychology

[22]Mukherjee, M. (2013, October 19).Health benefits of walking. The Times of India. Retrieved from April 14, 2014. http://timesofindia.indiatimes.com/life-style/health-fitness/fitness/Health-benefits-of-walking/articleshow/15568781.cms

[23]Newman, P. and Kenworthy, J. (1999). *Sustainability and cities: Overcoming automobile dependence,* Island Press, Washington, D.C.

[24]Nov, O., and Jones, M., (2003).Ordering creativity? Knowledge, creativity and social interaction in the advertising industry. Unversity of Cambridge. Retrieved from: http://www2.warwick.ac.uk/fac/soc/wbs/conf/olkc/archive/oklc4/papers/oklc2003_nov.pdf

[25]Owen, N., Leslie, E., Salmo, J., and Forthherungham, M. (2000). Environmental determinants of physical activity and sedentary behavior. *Excercise and Sport Science Reviews, 28(4):*153-158

[26]Pikora, T.J., Bull, F.C.L., Jamrozik, K., Knuiman, M., Giles-Corti, B., and Donovan, R.J. (2002). Developing a reliable audit instrument to measure the physical environment for physical activity. *American Journal of Preventive Medicine, 23(3): 187-194. doi:* http://www.sciencedirect.com/science/article/pii/S0749379702004981

[27]Roberts, KC.R., Shields, M.S., Groh, M.G., Aziz, A.A., Gilbert, J.G. Government of Canada Statistic Canada. (2012). *Overweight and obesity in children and adolescent from 2009 to 2011. Canadian health measures survey,* Retrieved from : http://www.statcan.gc.ca/pub/82-003-x/2012003/article/11706-eng.htmSaelens

[28]Saelens, B.E., Sallis, J., Black, J.B., and Chen, D. (2003). Neighbourhood-based difference in physical activity: An environment scale evaluation. *American Journa of Public Health, 93(9):*1552-1558

[29]Smith, P., Shalley, C.E., (2003). The social side of creativity: A static and dynamic social network perspective. *The academy of management review, vol. 28, No.1 (Jan. 2003)* .Retrieved from: http://www.creashock.be/CREASHOCK/eng/e_media/Downloads/The%20social%20side%20of%20creativity%20A%20static%20and%20dynamic%20social%20network%20perspective%20Perry-Smith%20Shalley.pdf

[30]Southworth, M. (2005) Designing the walkable city. *Journal of Urban Planning and Development, 131 (4),* 246-257

[31]Walk Score (2014).*Walk Score Methodology,* Walk Score. Retrieved from:https://www.walkscore.com/

[32]Winden, W.V., (2010). Creating liveliness and diversity in science locations Trends and examples; Urban IQ. Retrieved from: http://urbact.eu/sites/default/files/import/Projects/REDIS/outputs_media/Thematic_paper_1.pdf

APPENDICES

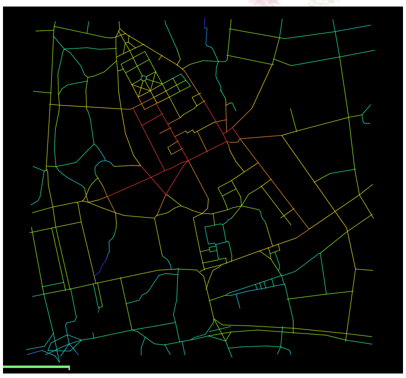
Appendix A1: Street sequence Sampling Criteria

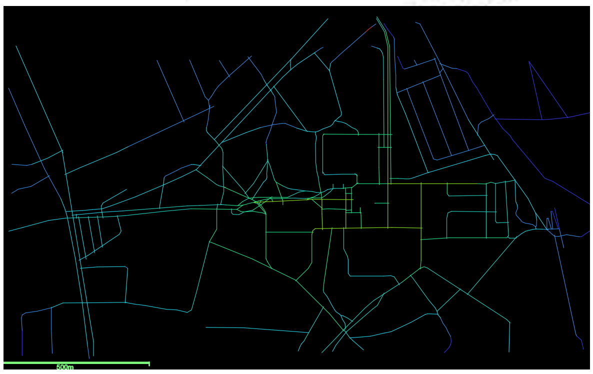
Selection criteria for sampling of streets for assessment.

1. Streets are selected so to form a continuous sequence (non-repeating) of pedestrian streets with start point and end point falling either in residential zone or transit zone running from periphery to central area and further ends at periphery again. Highest preference for the start point and end point will be given to residential zone and transit zone respectively.
2. The sequences should be made in such a way that it cover all the described zones in a definite order i.e. movement pattern of a typical undergraduate student.

Typical order:

3. The connection points within the intermediate zones should be chosen such that the corresponding segments length should be comparable among campuses. To achieve a comparable scale slight change (interchange) in order is acceptable but as a last option.
4. One sequence per campus is desirable for assessment in this dissertation. However, those selections would done by comparing all possible options, satisfying the above mention criteria. In the case of two very approximate sequences preference will be given to the sequence serving more space typology (1st) or more in length (2nd).





Appendix A2: Axial Analysis map (HH-integration at R1200)

Stadtmitte Campus, TU Darmstadt	Lichtwiese Campus, TU Darmstadt