Impacts of Library Space on Learning Satisfaction – an empirical study of university library design in Guangzhou, China

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1 Abstract

The current generation of millennial university students is more accustomed to searching reference information online than visiting the physical library facility, compared to the previous generations of students. Studies have shown that the role of the physical library facilities as a mere collection point of reading and reference materials is being threatened by the availability of free and high-speed online search engines. University libraries have always been an integral part in higher education learning activities, and they are not exempted from this threat. Based on a structural equation modelling framework, we analysed empirically the importance of different library design features that help enhance students' learning satisfaction, and found that lighting environment, acoustic environment as well as location of the library building were the main determinants impacting on the use of the university library by students in a major university in China. We conclude the paper with our suggestions in modifying library design to accommodate students' learning needs, and more importantly in reconfiguring the spatial and functional role of university libraries in this age of digital information from a mere provider of reference materials to a physical space of learning commons on campus.

Keywords : library design; learning satisfaction; university libraries; learning commons; SEM analysis

2 Introduction

Students studying at universities are more and more reliant on online library services as well as other online reference sites such as "Wikipedia" when searching for information to complete their coursework, or conducting general learning activities (Van Scoyoc and Cason, 2006, Thornton-Verma, 2012). This can be evident from the growing number of references in students' coursework or dissertations ending with the phrase : "*retrieved from*…". The ease of downloading academic papers/documents from any computer or smart phone students have access to is of course a major reason for this new learning behaviour. Virtual libraries have become a phenomenal development in the field of information and reference provision around the world when information and reference materials can be delivered to the users without their going into any physical library facility (Booth, et.al., 2002). Moreover, millennial undergraduate students nowadays are used to working in odd hours, such as midnight, when they cannot find access to a physical library. In this new age of online information, library as a confined physical location ceases to be the only source of reference information for university students, especially the undergraduate students who basically grew up in this era. Questions such as "do we still need libraries" or "do libraries still need books" (Carlson, 2002; Gray and Tracy, 2011; Buss, 2016) start to emerge in some research studies to reflect the current state of challenges physical library facilities face, namely, the spatial and functional role of a physical library facility nowadays. While we do not completely agree with

the existential crisis of library facilities, we do think that there is a need for library facilities to evolve with the socio-technological change in the university learning mode so that they can still maintain a vital role in enhancing students' learning satisfaction on campus. In doing so, we believe that university libraries can maintain the pivotal role of an essential part of higher education in the age of new information technology.

This paper intends to contribute to this debate on the spatial and functional role of library facilities in our urban environment based on an empirical analysis of a university library in China. This will provide a more scientifically robust foundation for our arguments and recommendations in the conclusion section at the end of this paper. This paper is divided into several sections. First of all, we will briefly discuss the correlation between university' learning environment and students' learning outcomes and satisfaction. Following this, we will discuss previous studies on the impacts of the spatial design of libraries on university students. In this paper, we examine university libraries as the target as opposed to public libraries in general because university libraries have always been one of the most integral parts in university education, and university libraries are symbolic to higher education learning philosophy (Cantwell, 2013). Built on this background of literature review on the role of physical library space, we conducted our empirical analysis in a major university in China, South China University of Technology (SCUT) in Guangzhou. By applying a structural equation modelling framework (SEM), we were able to decipher how university students view the spatial and functional role of university libraries and how different design aspects impact on their learning satisfaction on campus. The discussion section details our findings, followed by our conclusion in this study.

Learning environment and learning satisfaction in university education

Learning outcomes have almost become an important keyword in higher education curriculum design in the recent years. Learning outcomes measure how students excel during the period of studies at the university and how this will lead to better success for students, which is one of the main foci of higher educational institutions nowadays (Verešová, 2014; Jouhari, et.al., 2015). It fact, it has been described that learning outcomes of university students determine the function and objective of higher education (Liu and Chang, 2014). The American College Personnel Association (ACPA) and National Association of Student Personnel Administrators (NASPA) of the U.S. (2004) depict that in general, students' learning outcomes come under seven major categories, namely cognitive complexity, knowledge acquisition, integration and application, humanization/humanity, civic responsibility, interpersonal relationships and self-understanding ability, and continued schooling and academic achievements. Almost all of these cognitive and non-cognitive outcomes are developed, fostered and enhanced on campus during the study period. University education therefore provides an arena of training for these outcomes through learning and related activities carried out on campus as well as outside campus. In any case, these activities, especially those on-campus ones, are conducted within a learning environment specifically

designed to maximize such learning outcomes and satisfaction. The learning environment therefore must be able to fulfil the task of stimulating students' desire to quest for new knowledge. This includes providing physical space on campus that allows students to carry out interactive learning exercises that facilitate "learning by doing" (Dzeng, et.al., 2014).

Nevertheless, since our questionnaire survey covers students (mainly undergraduate students) from various academic programmes on the SCUT campus in Guangzhou, China, it becomes difficult to measure learning outcomes objectively among these students from very different academic programmes. Consequently, the dependent variable has been set to be the learning satisfaction among the users of the university library in our SEM analysis, which will be explained in further below.

Hence, to achieve better university learning satisfaction, it is therefore imperative to incorporate the element of motivation in the learning environment. Motivation to study and learn on the other hand depends on a number of other exogenous and endogenous factors, including teaching style, guidance and feedback given by the instructors, and more interestingly, gender of the students (Chesbrough, 2011; Özütürk, & Hürsen, 2014; Ro and Knight, 2016).

The main objective of this paper, therefore, is to empirically examine the relative importance of different environmental variables that exist in university library space to learning satisfaction among university students by means of a robust scientific model of SEM. Through a large scale questionnaire survey on the SCUT campus, the views of the library users (mainly undergraduate students) were deciphered and significant variables were identified and highlighted in the testing model. The outcomes of the analysis will help contribute to the current discussion on how to facilitate libraries, especially university libraries, to become a pivotal physical space for learning in the age of digital information for university students.

3 Physical library facilities and learning

Libraries are traditionally physical facilities that provide a concentration of book collections for sharing among a specific group of users (such as university libraries) or the general public. However, in this age of digital information, finding references for academic research or completing assignment is less and less dependent on the physical visits to libraries. Online reference search starts to be viewed as a more effective replacement or even as a threat to physical library collections (Odling-Smee, 2007; Rapp, 2011; Little, 2011). In essence, library space works as a central distribution and circulation platform for book-sharing activities. As it evolves, library as a physical space takes up an addition role of providing a comfortable, quiet and safe environment for self-regulated learning activities as well. Although access to space within library is open to

public or to a specific group of users within a certain community, library space becomes a sanctuary for book-lovers in a "free of judgment" environment (Row, 2017). This is feasible mainly because of the management of library space within the facilities. "Quietness" is a common denominator in all kinds of libraries, except for specific sections in the library, as users are supposed to conduct reading activity only. Hence, verbal discussions are usually forbidden in most areas of the library building, and users can enjoy reading or working on their own without being disturbed by others. This makes libraries important as they take up the role of "learning commons" for people without the privilege of privacy at home. Hence, there exists a strong tie between library facility as a physical space and learning satisfaction of the users that has been shown to be of important academic interests (Rudzioniene, 2014; Cullen, 2014; Bilandzic & Foth, 2014; Jolly and White, 2016). Since libraries, especially university libraries, are specifically built for such purpose, satisfactory collaboration between library design features and learning environment allows maximization of learning satisfaction if such correlation is well-recognised and applied. In additional to conventional functions, Bilandzic & Foth (2014) have also shown that architecture characteristics of library space can play a significant role in highlighting the social attribute of library facilities in amplifying the social interactions among visitors to the library. Such informal learning space incorporated as part of the campus environment within the university library is equally important in higher education agenda (Deed and Alterator, 2017). In this way, libraries still maintain an important learning and social role in the age of digital information, as long as the design and management team of academic libraries understand the needs of the users and appreciate that there are aspects which just cannot be replaced by digital technology, including communications and interactions among users, appreciation of culture and arts, as well as the sense of scholarship and inspiration inside the library facilities (Stojanovski, J. (2013, Palfrey, 2015; Jolly and White, 2016), not to mention the fact that it is still doubtful if digital giants such as Google can actually digitize all collections of books in a cost-effective way (Fialkoff, 2011; Palfrey, 2015). More importantly, university administrators should also recognize the unique nature of library space in promoting university learning culture, rather than treating library space as a surplus physical space that can be consumed by other units for non-learning related activities from time to time.

Given the importance of design features of library space to the learning satisfaction of users, researchers start to advocate user-oriented design principles that allow multifunctional space to motivate effective learning among library users to be taken into consideration when designing and building libraries. By incorporating the users' views through surveys, novel idea such as co-design model can help build libraries that can maximize their academic and social functions (Tevaniemi, et.al., 2015). Ellison (2016) echoes in her studies with this need for incorporating the views of the library users when designing academic libraries that promote better learning outcomes. Her studies show very detailed design features such as lighting, signature and desk space that are influential to students' learning activities. In the other words, when designing library facilities, considerations should be given to the evolving role and functions of library space from the users'/visitors' perspective, as they are given more choices nowadays in sourcing reference information and materials. For library space to become more functional and valuable to the users,

design features of library facilities should enhance other role and function that are not easily replaced by the digital transformation in our society, namely as a place to enrich and enhance learning experience, academically and socially for the users. In the following, we will contribute to this aspect of the built environment research with a more scientific method of structural equation modelling (SEM) that will help us understand more about the impacts of library facilities design and spatial arrangements. This will also contribute to the current debate on whether and how the advent of high speed information in the digital age will drastically replace or displace some of our traditional social space such as libraries in our urban environment.

4 Methodology

Structural Equation Modelling (SEM) is adopted in this paper as the core analytical framework. SEM includes a diverse set of mathematical models, computer algorithms, and statistical methods that fit networks of constructs to data. Our main explanatory variables are the impacts of environmental and design features of university library on students' learning satisfaction. They are all abstract concepts in nature (latent variables) and we measured them through various indicators in our analysis. SEM allows us to diagnose which observed variables are good indicators of the latent variables. This is the measurement model, one of the two main SEM components. The other main component is the structural model, which lays out the relationships among latent variables from a theory or hypothesis. Basically, SEM combines factor analysis and multiple regression analysis. Structural model consists of several latent variables and path relationship between variables. The effect of a path can be obtained through using the structural equation model. SEM is suitable for this project because it assesses the multiple and interrelated dependence among all the variables in a single analytical framework.

The latent variables of SEM are reflected by multiple-observed variables, avoiding the multicollinearity problem between independent variables in traditional linear regression. In addition, SEM allows multiple dependent variables in a model at the same time, which solves the problem that only one dependent variable is allowed in the traditional linear regression. Combined with the actual situation of this study, SEM is used to explore the key design points of university library that affect students' learning satisfaction in our sample.

Moreover, SEM is chosen in this research for its versatility that can be applied in different fields of research. SEM has been widely adopted in the medical and health care research field for a better understanding of the factors leading to certain illness or those that will help improve the patients' problems, as these factors sometimes tend to intertwine with each other and are difficult to examine individually (Cois and Ehrlich, 2014; Alessandrini, et.al., 2016; Castro, et.al., 2016; Mitchell, et.al, 2017; Lewis, et.al., 2017). In addition, because of its capability to dissect latent variables with multiple observations, SEM has also been adopted in other academic fields. For instance, SEM

has been applied in the examination of the factors affecting aggressive behaviours (McKay, et.al., 2016); in the study of work-family-school conflicts and social support for the medical care profession (Goong, et.al., 2016); in the analysis of the factors contributing to the sustainability of cities that depend on heavy industry (Zhang, et.al., 2016); in the study of planned behaviour in the utilisation of natural resources with supply shortage, such as water (Cooper, 2017); in the examination of strategic management of public institutions such as universities (Dandagi, et.al., 2016); as well as in general business production and marketing analysis (Martínez-López, et.al., 2013; Thirupathi and Vinodh, 2016; Pal Pandi, et.al., 2018; Ajayi and Oyedele, 2018). This paper therefore intends to contribute to this rich body of literature on the application of SEM with a specific angle of the changing spatial and functional role of academic libraries in the age of digital information in enhancing students' learning satisfaction.

In this paper, data to be utilized in the SEM analysis will be collected from a major university in China, the South China University of Technology (SCUT) in Guangzhou, China. There are a number of reasons for this choice. South China University of Technology (SCUT) is one of the top universities directly under the Ministry of Education in China, and student quality is therefore also very high, leading to a reasonable assumption of higher frequency in library visits at SCUT. Moreover, the architectural design programme at SCUT is ranked the 5th among all the national higher education institutions in China. In this research, the SCUT Library was designed and renovated by the Architectural Design and Research Institute (ADRI), a subsidiary of SCUT, in 2017. Therefore, this library can represent a combination of advanced design theories as well as professional practice in architecture. Moreover, some of the staff at the ADRI are also teaching staff and graduate students of SCUT, the design of the university library should therefore have got input from the users' point of view from the very beginning. Since the objective of this paper is to examine the spatial and functional role of university library in the current age of digital information when reference search is made more easy at home, an academic library recently designed and built by a professional team with direct and indirect connection to and knowledge of the university's learning environment should help illuminate our results.

According to the literature review elaborated above, there are not a lot of studies devoted to analysing and evaluating library learning environment empirically for us to develop an evaluation system on satisfaction level from users' point of view. This may be due to the fact that traditionally, libraries are regarded as "confined space" holding the collection of books and reference materials in our urban society (Nicholas, et.al., 2011), and hence the spatial role of libraries in our urban city tends to be more on the enhancement of accessibility to these reference materials in different urban districts. In order to identify the relevant environmental factors within the library facility that may impact on students' learning satisfaction for our studies, we need to create an evaluation system, based on a general literature review on environmental impacts on work efficiency and performance outcomes of users in a confined physical space. For example, Banbury and Berry (1998) find that noise is a major factor affecting staff productivity as it reduces memory performance and mental computing capacity of staff. Groth (2007) believes that lighting can affect people's behaviour, and

consequently productivity, which echoes with the study by Ketutwijaya (2012). In addition, it has been found that poor indoor air quality (including high carbon dioxide concentrations) can affect students' learning ability (Lee, et.al., 2012; Choi, et.al., 2014). Furthermore, the general learning environment on campus as well as accessibility of the physical facilities have all been regarded as important factors (Castilla, et.al. ,2017).

Consequently, after reviewing these various studies, we have finally arrived at a total of six major categories of environmental factors pertaining to our analysis of library spatial design that may impact on students' learning satisfaction. These six categories will form the basis of our evaluation system, they include acoustic environment, light environment, air quality, learning space, learning facilities, and accessibility ("accessibility" in this paper is specifically defined as the ease of reaching the library by the students either on foot or by school bus from their student quarters on the SCUT campus). Each category can be further sub-divided into individual variables in our questionnaire survey (Fig.1). In our analysis, we will also include two paths in the analytical framework as major parameters contributing to students' learning satisfaction as these two paths seem to be more relevant to learning satisfaction. These two paths are visit time to the university library and respondents' learning status. Learning status is generally defined as two major directions, namely learning efficiency and learning attention (Everaert, et.al., 2017). These two paths form a structural relationship together as the evaluation system of the variables in the six categories outlined above. The overall structural relationship on how they may impact on learning satisfaction of university students in our model is illustrated in Fig. 1 below. The evaluation will be carried out through the Structural Equation Modelling (SEM) at a later stage.

Based on these six categories of latent variables, we then proceed to the SEM analysis, with data obtained from a questionnaire survey designed for and distributed to students (mainly undergraduate) and a few research staff in early 2018 on the campus of SCUT (the full questionnaire is attached in the Appendix). The questionnaire mainly consists of four parts, namely, personal details of the respondents, their learning behaviour, evaluation on their satisfaction of individual library learning environment variables and the overall satisfaction of the learning environment in the SCUT library. Objective answers were collected based on a Likert 7-scale method. The questionnaires were distributed through online social network applications and face-to-face contacts in the library and various classrooms on the SCUT's main campus in early 2018. A total of 529 questionnaires were collected in this survey, of which 462 were decided to be valid for analysis and the effective rate was 87.33%.

4.1 Data analysis and results

Table 1 shows the personal characteristic of the respondents. The gender ratio of the whole sample is very near to the gender ratio of undergraduate students at the SCUT campus. It reflects a balanced distribution of respondents.

Table 1 Personal characteristic of respondents.

Personal characteristic	category	quantity	% Distribution
Gender	Male	275	59.5%
	Female	187	40.5%
Age	Below 18	1	0.2%
	18~20	122	26.5%
	21~23	251	54.3%
	24~27	75	16.2%
	Over 28	13	2.8%
Academic status	Undergraduate Year 2	93	20.1%
	Undergraduate Year 3	131	28.4%
	Undergraduate Year 4	117	25.3%
	MDC year 1	53	11.5%
	MDC year 2	27	5.8%
	MDC year 3	21	4.6%
	Doctoral candidate	13	2.8%
	Teaching and research staff	3	0.6%

	Others	4	0.9%
Residential location / students' quarter districts (see Fig. 1 below)	East	127	27.5%
	West	186	40.3%
	North	135	29.2%
	South	3	0.6%
	Others	11	2.4%

Notes :

1. MDC- Master Degree Candidate
2. Year 1 undergraduates are not included in this survey since they study and live in another campus in the Guangzhou University town.
3. There are mainly four students' quarter districts (see Fig. 1 below):

   East District is about 0.7 km away from the library which needs 9 minutes of travelling on foot.

   West District is about 0.85 km away from the library which needs 11 minutes of travelling on foot.

   North District is about 2.3 km away from the library which needs 29 minutes of travelling on foot.

   South District is about 0.6 km away from the library which needs 8 minutes of travelling on foot.

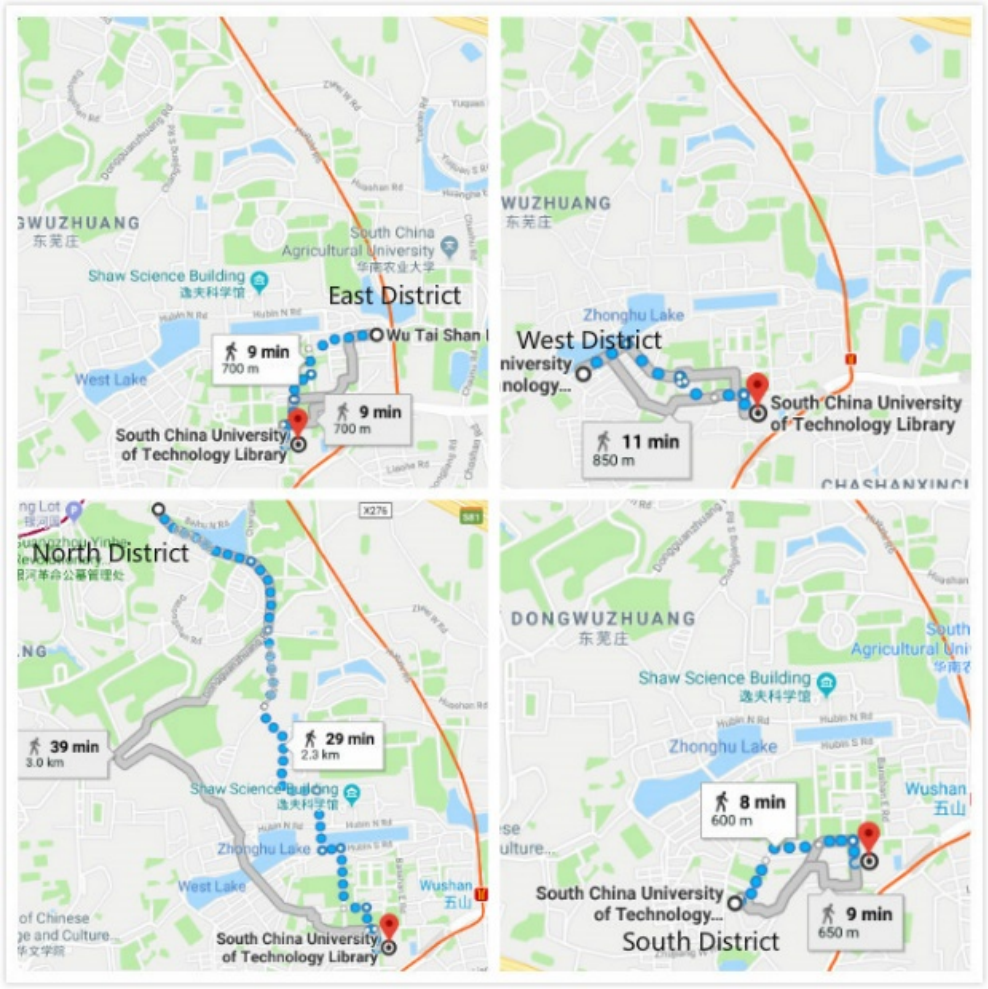

Fig. 1 Geographical distribution of major students' quarters on SCUT campus

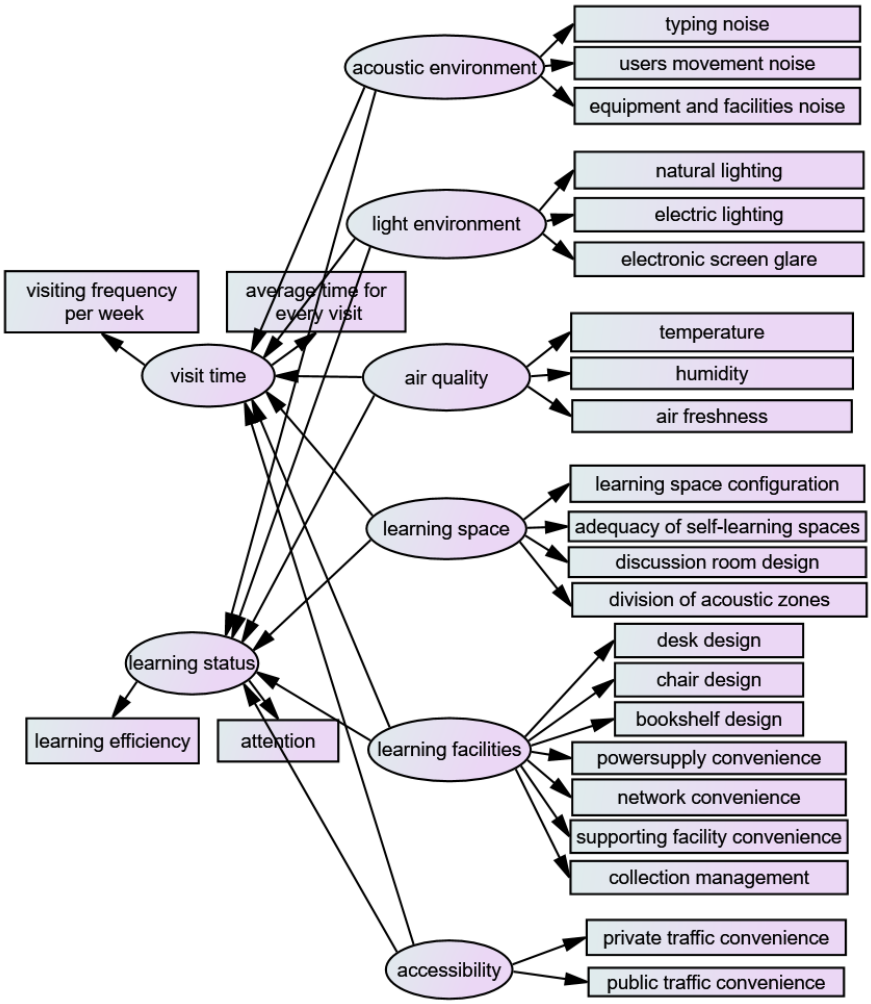

Fig. 2 Evaluation system and initial structural equation model

Fig. 2 above illustrates that there are a total of 22 library environmental variables listed as potentially relevant to learning satisfaction. Before we carried out the SEM analysis, we needed to further analyse whether all these variables are significant or not. To achieve this objective, we conducted the exploratory factor analysis (EFA).

4.2 Exploratory Factor Analysis (EFA) of the independent variables

Exploratory Factor analysis was applied to extract the common factors from the library learning environment variables. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was

calculated at 0.844, which was considerably higher than the required minimum (Table 2). The KMO data represents a strong correlation between variables which are suitable for exploratory factor analysis. According to the difference of extraction results and research assumptions, unreasonable items were omitted. Then, the common factors were extracted again. A scree plot was created which showed that the number of dimensions involved seven significant variables only (Fig. 3). Table 3 shows the solution accounted for 66.378% of the total variance in the questionnaire. Variables were categorized and grouped, as shown in Table 4. Table 4 indicates that from the original total 22 variables, 19 of them were found to be significant and relevant and they were kept in the model.

Table 2 KMO and Bartlett's test

Kaiser-Meyer-Olkin measure of sampling adequacy		0.844
Bartlett's test of sphericity	Approx.chi-square	1907.896
	df	171
	Sig.	.000

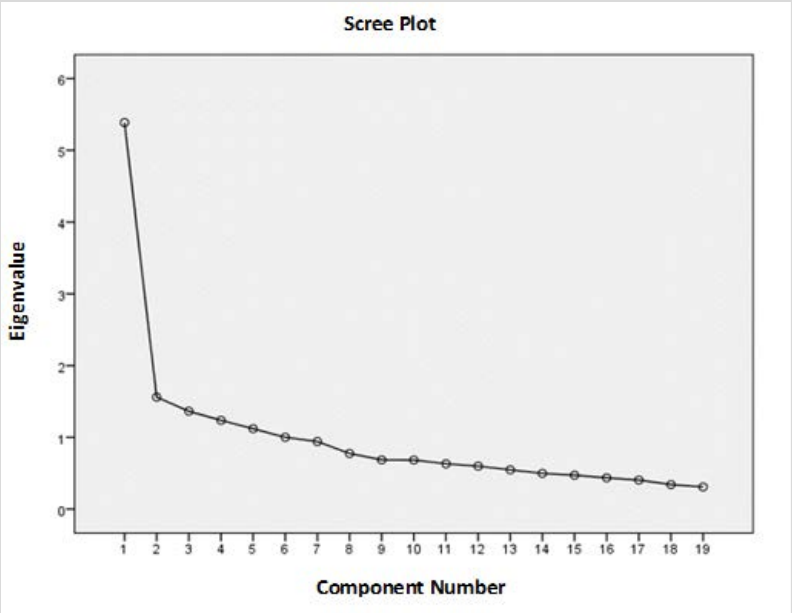

Fig. 3 Scree plot of eigenvalues on all factors

Table 3 Total variance explained

Component	Initial eigenvalues		
	Total	% of Variance	Cumulative %
1	2.001	10.534	10.534
2	1.948	10.252	20.786
3	1.932	10.170	30.956
4	1.726	9.086	40.042
5	1.705	8.975	49.017
6	1.666	8.766	57.784
7	1.633	8.595	66.378

Table 4 Rotated component matrix and grouped variables

Categories	Factors	Factor loading
Light environment	Natural lighting	0.773
	Electric lighting	0.711
	Electronic screen glare	0.630
Learning supporting facility	Collection management	0.776
	Bookshelf design	0.679
	Supporting facility convenience	0.599
Air quality	Temperature	0.824
	Humidity	0.816
	Air freshness	0.538
Acoustic environment	Typing noise	0.804
	Users movement noise	0.769
	Equipment and facilities noise	0.533
Accessibility	Private traffic convenience*	0.886
	Public traffic convenience#	0.878
Self-learning space	Adequacy of self-learning spaces	0.861
	Learning space configuration	0.651
	Discussion room design	0.542
Desk and chair design	Chair design	0.818

	Desk design	0.766

Notes :

**- Private traffic convenience refers to walking on foot, riding personal bicycles or driving private vehicles(which is mainly applicable to research staff in the sample).*

#- Public traffic convenience refers to taking school buses or taking the shared bikes on campus.

4.3 EFA of the dependent variables

Exploratory Factor analysis was then applied to extract the common factors from learning behaviours for the dependent variables. The Kaiser-Meyer-Olkin measure of sampling adequacy were calculated at 0.525, which was considerably higher than the required minimum (Table 5). The KMO data represents a strong correlation between variables which are suitable for exploratory factor analysis. Table 6 shows the solution accounted for 77.05% of the total variance in the occupant questionnaire. Variables were categorized and grouped, as shown in table 7.

Table 5 KMO and Bartlett's test

Kaiser-Meyer-Olkin measure of sampling adequacy		0.525
Bartlett's test of sphericity	Approx.chi-square	300.948
	df	6
	Sig.	.000

Table 6 Total variance explained

Component	Initial eigenvalues		
	Total	% of Variance	Cumulative %

1	1.682	42.045	42.045
2	1.400	35.000	77.045

Table 7 Rotated component matrix and grouped variables

Categories	Factors	Factor loading
Learning status	Attention	0.916
	Learning efficiency	0.912
Visit time	Visiting frequency per week	0.841
	Average time for every visit	0.826

4.4 Confirmatory Factor Analysis (CFA) of the independent variables

CFA was further performed to test the fitness between optimized measurement models and data collected. The optimized measurement models of exogenous latent variables were drawn in the AMOS. As shown in Fig. 4, the factor loadings for all items were above 0.5, so no item deletion was required at this point. The fitness indices were then assessed and they showed that the model was a good fit. The basic fitness index is presented in Table 8.

When the significance of Chi-square degree of freedom is less than 0.05, it indicates that there is a significant difference between model and actual data. In fact, large samples are usually difficult

to guarantee that the value of significance is more than 0.05. Thus, it is necessary to test other fitness indices. Since both GFI and AGFI exceeded 0.9 as shown in Table 8, they indicated that the model was an acceptable fit. The value of RMSEA was less than 0.05, indicating that the model was not affected by the number of samples and the complexity of the model. In addition, since PGFI was larger than 0.5, the model was shown to be a good fit.

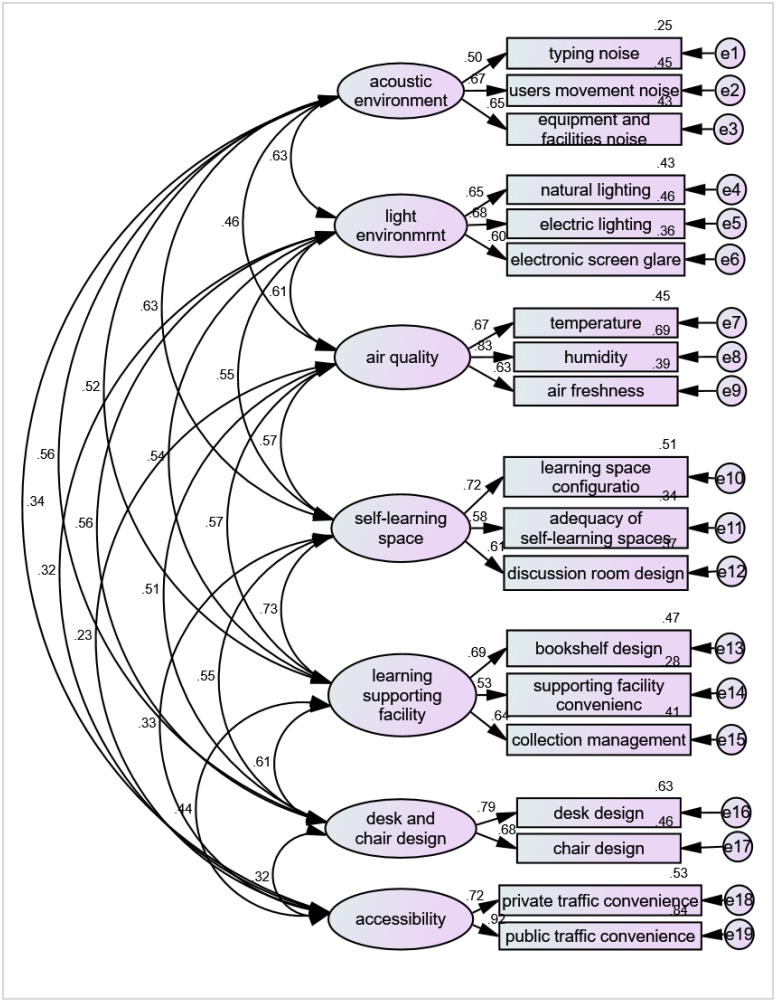

Fig. 4 CFA of independent variables

Table 8 Fitness indices (measurement model of independent variables)

indices	Appropriate range	Actual Value	Fit Judgement
Sig.	>0.05	0.000	No
Chi-square degree of freedom	<2.00	1.588	Yes
RMSEA	<0.08	0.04	Yes
GFI	>0.90	0.94	Yes
AGFI	>0.90	0.913	Yes
PGFI	>0.50	0.648	Yes

4.5 CFA of the dependent variables

In the next step, the endogenous latent variables were drawn in the AMOS. The basic fitness index is presented in Table 9. It also suggests that the model is a good fit.

Table 9 Fitness indices (measurement model of dependent variables)

indices	Appropriate range	Actual Value	Fit Judgement
Sig.	>0.05	0.509	Yes

Chi-square degree of freedom	<2.00	0.436	Yes
RMSEA	<0.08	0.000	Yes
GFI	>0.90	0.999	Yes
AGFI	>0.90	0.994	Yes
PGFI	>0.50	0.100	Yes

4.6 Path analysis

Through EFA and CFA, a reasonable structural equation model was finally obtained. After the insignificant influence paths were deleted, the final structural equation model was obtained which had four significant paths. (Fig. 5a and Fig.5b) The basic fitness index is shown in Table 10. At this stage, the model is proved again to be a good fit.

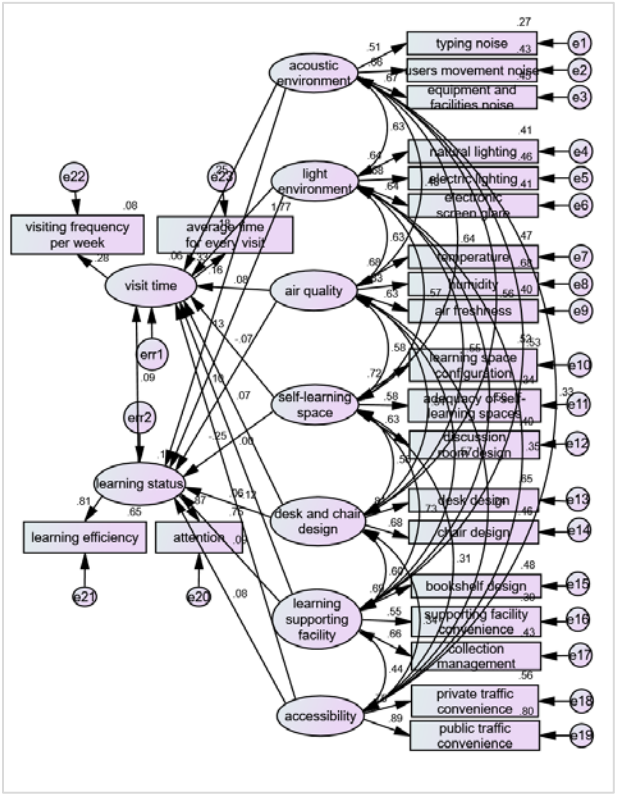

Fig. 5a Initial structural equation model after CFA

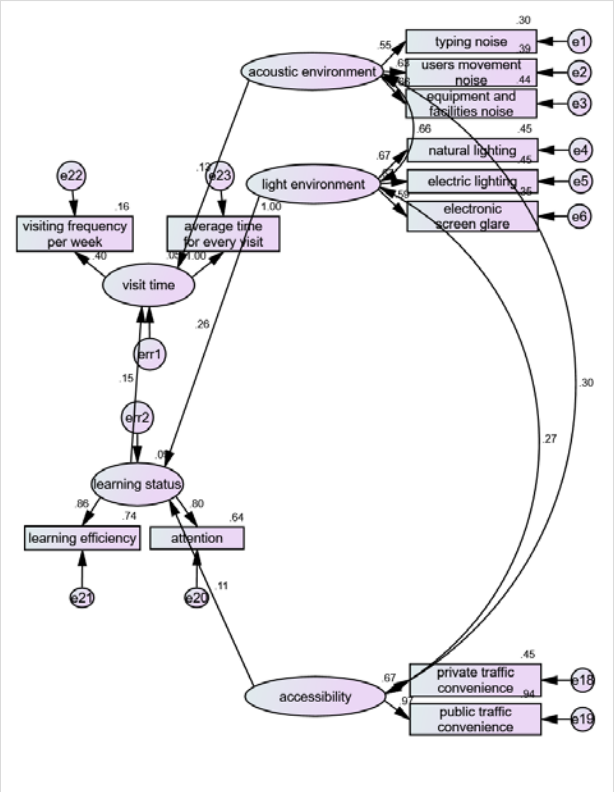

Fig. 5b Final structural equation model

Table 10 Fitness indices of final structural equation model

indices	Appropriate range	Actual Value	Fit Judgement
Sig.	>0.05	0.026	No
Chi-square degree of freedom	<2.00	1.436	Yes
RMSEA	<0.08	0.034	Yes
GFI	>0.90	0.969	Yes
AGFI	>0.90	0.949	Yes
PGFI	>0.50	0.569	Yes

To finalise our structural equation model, we carried out a stepwise regression to test whether the four paths were significant. Table 11 shows that these four paths identified are statistically significant.

Table 11 Parameter Estimates of final structural equation model

Path	Standardized regression weights	S.E.	C.R.	P	Label
Learning Status ⟵ Light environment	0.256	.074	3.153	.002	par_9
Learning Status ⟵ Accessibility	0.110	.059	1.699	.089	par_10

Visit time ⟵ Acoustic environment	0.129	.070	1.723	.085	par_8
Visit time ⟵ Learning Status	0.149	.056	2.214	.027	par_14

Discussion of results

Our SEM analysis shows that some internal design criteria for university libraries are significantly relevant to the learning satisfaction of the students using the university library space. For university libraries to provide the spatial function of a learning commons, in addition to a confined space for reference materials, some design features need to be considered. First of all, our study finds that students at SCUT still rely on the physical space provided by their university library to study and to carry out self-learning. As a result, satisfactory lighting design will affect their degree of learning satisfaction. Lighting facilities affect directly the comfort of students' eyes when they are reading inside the library. After conducting on-site analysis, we find that the lighting environment varies with different sections of the SCUT library building. For some reasons, there are no curtains hung on the windows of the library. As a result, the eastern part of the library tends to benefit from natural lighting in the morning, while such natural light will switch to the western part of the facility in the afternoon (Fig. 6a). On the other hand, some areas in the interior lack both natural and artificial lightings all the day, leading to lower popularity when students have a choice, or unsatisfactory learning outcomes when they do not have a choice but have to settle for these areas (Figure 6b). In terms of lighting environment, there is no gender difference in terms of satisfaction level.

Fig. 6a : Natural lighting

Fig. 6b : Artificial lighting

Secondly, the satisfaction level of acoustic environment has shown to have a significant impact on the visit time. While most people associate the word “silence” immediately with libraries, it does not preclude noise from emerging inside the library facility, even students are not deliberating talking to each other. Most students do respect the basic rule of using the library, ie. to be quiet. However, one’s normal learning behaviour may inadvertently impact on others negatively. Studying in the age of information means that students will also bring along their notebook computer with them for working on their assignments as well as conducting internet search. When all students are learning in a confined public space, the noise produced by students when typing on their notebook computer will amount to quite a substantial level. Such a level of working noise will eventually affect other students who are reading or trying to concentrate on their work. Interestingly enough, male students tend to be more tolerant of such working noise generated from typing than female students.

On the other hand, as noticed from Fig. 6a and Fig. 6b, the floor of SCUT library is not carpeted for easy maintenance reason. However, it creates another noise problem, which is the noise generated by foot-traffic. Noise generated by foot-traffic is a predicament for well-designed library space. Good learning environment attributed to good design features contributes to students’ higher learning satisfaction level. Good learning environment therefore attracts more students to utilize the library space for studying and learning, leading to higher volume of foot traffic in most part of the library facilities, which will inevitably generate negative noise impact (Fig. 7 and Fig. 8). However, different from typing sound generated from using notebook computer, foot-traffic noise tends to be transient and sporadic, and not all students feel the same towards such noise. Students who are more sensitive to such footstep noise will eventually shy away from using the library for learning when they need a more tranquil environment to do so. Our results show that students who are not satisfied with such noise environment will reduce learning time spent inside the library.

Fig. 7 Design of learning area and book collection

Fig. 8 Self-learning area

Thirdly, our results also show that the accessibility satisfaction, namely the ease of reaching the library, has a significant impact on learning satisfaction. Accessibility in our study refers to the travel time for students to get to the library. In Mainland China, almost all students are required to live in student quarters on campus. In our study, we factored the location of respondents' quarter into the analysis. Since some student quarters are farther away from the SCUT library which requires taking vehicular transportation (in particular, North District in Fig. 1 above), our results show that students who don't have to spend a lot of time on travelling to and from the library tend to spend more time in the library. In addition, they also report better learning satisfaction compared to those who do not have the same accessibility advantage. Again, there is no gender difference in terms of satisfaction level in this variable.

5 Conclusion

We set out to examine the spatial and functional role of academic library within university campus in the age of high-speed information technology when most students can easily find academic reference materials online anywhere and everywhere they go. While recent studies show that the role of library as a confined space holding collection of reading materials may be under threat by the advent of powerful online reference search engines and platforms, we notice that university libraries still maintain an irreplaceable role of being a learning commons. Our study in Guangzhou illustrates that this is especially the case where most students are still living on or near the campus, and student quarters/dormitories may not be ideal for their learning outcomes. Based on a robust SEM analytical framework and reinforced by various model fitness tests, our study confirms this spatial and functional role offered by the university library that helps students to enhance their learning satisfaction, as long as a certain design criteria are thoroughly considered in configuring the physical space of library facilities.

Among all the library environmental variables identified as significant to learning satisfaction in this paper, we find three major areas with significant impact on university students' learning behaviour, as well as their willingness to visit the library facilities. From our results, there are three library learning environment categories which have significant impacts on learning satisfaction, namely, lighting environment, accessibility and acoustic environment. Interestingly enough, our respondents seem to enjoy natural lighting and they tend to follow such natural sunlight for studying inside the library. One possible explanation for this is that artificial lightings in academic buildings on campus in Mainland China are usually not adequate. Hence, lighting design in the study areas that will help students' learning outcome on university campus should be enhanced. We notice that in the recent decades, national investment on higher education in China has increased substantially, but mainly in research funding. Investment on university teaching and learning facilities, such as university libraries, should be strategically allocated as well. There should be a more diversified and balanced funding allocation between book collection and physical space design/library facilities. This is especially true when e-journals and e-books are getting more and more common and affordable, and the existence of academic libraries now depends more on how the environmental attributes of the confined space can help students' learning activities to become more satisfactory.

Similarly, acoustic environment is also very important to students using the library as a learning facility. From our study we recommend, in terms of architectural design requirements, that the self-study areas can be divided into purely reading section and working section. The former can impose stricter rules on the use of electronic equipment with better design such as carpeted floor, while the latter can allow a higher degree of students' interaction, including group discussions among students. In this way, students with different learning needs and requirements can visit the section that accommodates their study needs. Moreover, entrances, exits, as well as staircases should be far away from the self-study areas to minimize noise generated by foot traffic. Thirdly, in terms of location of the university library, where the campus is relatively large, and student quarters tend to scatter all over the campus, we suggest enhancement in transportation arrangement, especially at night for safety concerns among female students. Where funding and space are both available, satellite libraries/learning centres could be set up near remotely-located quarters to increase the accessibility of university library.

To conclude, we find that although the current generation of millennials grew up in the high-speed information age and have been accustomed to finding reference materials online rather from visiting the physical library facility, this does not relegate the spatial and functional role of libraries to just a simple storage space. University libraries are an important platform for students' learning activities. University libraries as a well-designed confined space that accommodate students' learning requirements are still instrumental in enhancing their learning outcomes and satisfaction,

and library as a learning commons still commands a significant role in higher education development, as well as in the community in general.

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APPENDIX

Questionnaire on learning environment satisfaction of South China University of Technology Library

The first part consists of your personal basic information and learning behaviour.

1. Gender of the respondent

a. Male b. Female

2. What is your age?

a. Under 18 years b. 18 years c. 19 years d. 20 years e. 21 years f. 22 years g. 23 years h. 24 years i. 25 years j. 26 years k. 27 years l. 28 years or over

3. How would you describe your status at SCUT?

a. Undergraduate Year 1 b. Undergraduate Year 2 c. Undergraduate Year 3 d. Undergraduate Year 4 e. MDC year 1 f. MDC year 2 g. MDC year 3 h. Doctoral candidate. i. Teaching and research staff j. Others

4. What is your current residential location?

a. East district of SCUT b. West district of SCUT c. North district of SCUT d. South district of SCUT. e. Others

5. How often do you visit the Library of SCUT?

a. Never b. Once a week c. Twice a week d. 3 times a week e. 4 times a week f. 5 times a week g. 6 times a week h. 7 times a week i. 1~3 times a mouth j. Others

6. What is the average time you spend in the library on an average day ?

a. 0~2 hours b. 2~4 hours c. 4~6 hours d. 6~8 hours e. 8~10 hours f. 10~12 hours g. 12~14 hours h. over 14 hours

Next, you can tick a box that best represents your view in the following questions

7. What do you think of your learning efficiency inside the library?

Low	1	2	3	4	5	6	7	High

8. How easy can you concentrate on learning inside the library?

Easily Distracted	1	2	3	4	5	6	7	Highly concentrated

The second part focuses on your satisfaction of the library learning environment.

9.

	Very dissatisfied → **Very satisfied**						
Laptop typing noise (mouse, keyboard)	**1**	**2**	**3**	**4**	**5**	**6**	**7**

10.

	Very dissatisfied → **Very satisfied**						
Foot-traffic noise	**1**	**2**	**3**	**4**	**5**	**6**	**7**

11.

	Very dissatisfied → **Very satisfied**						
Equipment and facilities noise (air conditioner, drinking fountain, etc.)	**1**	**2**	**3**	**4**	**5**	**6**	**7**

12.

	Very dissatisfied → **Very satisfied**						
Natural lighting of learning space	**1**	**2**	**3**	**4**	**5**	**6**	**7**

13. **Very dissatisfied** ——→ **Very satisfied**

Artificial lighting of learning space	**1**	**2**	**3**	**4**	**5**	**6**	**7**

14. **Very dissatisfied** ——→ **Very satisfied**

Electronic screen glare (laptop, mobile phone)	**1**	**2**	**3**	**4**	**5**	**6**	**7**

*Glare means that extreme brightness contrast which can cause visual discomfort.

15. **Very dissatisfied** ——→ **Very satisfied**

Indoor temperature	**1**	**2**	**3**	**4**	**5**	**6**	**7**

16. **Very dissatisfied** ——→ **Very satisfied**

Indoor humidity	**1**	**2**	**3**	**4**	**5**	**6**	**7**

17. **Very dissatisfied** ——→ **Very satisfied**

Indoor air freshness	**1**	**2**	**3**	**4**	**5**	**6**	**7**

18. **Very dissatisfied** ——→ **Very satisfied**

Desk design	**1**	**2**	**3**	**4**	**5**	**6**	**7**

19. **Very dissatisfied** ——→ **Very satisfied**

Chair design	**1**	**2**	**3**	**4**	**5**	**6**	**7**

20. Bookshelf design

Very dissatisfied ——→ **Very satisfied**

1	2	3	4	5	6	7

21. Power supply convenience

Very dissatisfied ——→ **Very satisfied**

1	2	3	4	5	6	7

22. Network/wifi convenience

Very dissatisfied ——→ **Very satisfied**

1	2	3	4	5	6	7

23. Supporting facility convenience (storage locker, etc.)

Very dissatisfied ——→ **Very satisfied**

1	2	3	4	5	6	7

24. Collection management (recovery efficiency, Extent of books collection, etc)

Very dissatisfied ——→ **Very satisfied**

1	2	3	4	5	6	7

25. Configuration of learning space

Very dissatisfied ——→ **Very satisfied**

1	2	3	4	5	6	7

* The learning space configuration reflects the degree of over-crowdedness in the study areas inside the library.

26. **Very dissatisfied** ——————→ **Very satisfied**

Adequacy of self-learning spaces

1	2	3	4	5	6	7

27. **Very dissatisfied** ——————→ **Very satisfied**

Discussion room design

1	2	3	4	5	6	7

28. **Very dissatisfied** ——————→ **Very satisfied**

Division of acoustic zones

1	2	3	4	5	6	7

29. **Very dissatisfied** ——————→ **Very satisfied**

Private traffic convenience (walking, private bikes or cars)

1	2	3	4	5	6	7

30. **Very dissatisfied** ——————→ **Very satisfied**

Public traffic convenience (shared bicycles and school buses)

1	2	3	4	5	6	7

31. **Very dissatisfied** ——————→ **Very satisfied**

Overall learning environment

1	2	3	4	5	6	7

Thank you for your cooperation.