Modular Principles for Flexibility of Spaces in Skill Acquisition Centres, Benue State

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Abstract

The design of skill centre around the country is such that they are specific to particular skill type and usually the buildings cannot be used for another activity. The need to use spaces for multiple functions has ensured that flexible spaces in skill acquisition centres are designed such that the spaces can easily be varied into smaller discrete and scalable sizes. This paper examined the interior spaces for pedagogical and didactic activities in six selected skills acquisition centres in Benue state. The issue of the rigidity of spaces occurring as product of the building design which is meant to serve a required function usually ensures that spaces are less flexible and in many cases unusable for other functions. The aim of the study is to examine the flexibility nature of skill centres with a view to determining functions that could be combined. A post occupancy evaluation was carried out using a mix method approach through the use of observation checklist and questionnaire. The issues examined include the various sizes of workshop spaces, walling materials used to enclose spaces, the degree of flexibility of both spaces and materials based on modular principles and users' perception of satisfaction of working spaces. A total of 300 copies of questionnaires were administered to staff and students. Based on the total valid responses, 70% were not satisfied with the sizes of the working space. The resultant data obtained was analysed using descriptive statistics from SPSS. It was observed that most spaces though modular were non-flexible. Users' satisfaction with the sizes of working spaces was determined. The paper concluded on the need for the flexibility of spaces in order to accommodate varying utility.

Keywords: Flexibility, Interior Spaces, Modular Space, User Satisfaction, Working Space

Introduction

There is significant dwindling economic income for many countries around the world of which Nigeria is not an exception. The need for people to undertake some form of vocational training has become imperative and the resource to build these training centres has increasingly become unavailable. The usual practice of architects in the past was to simply design buildings to meet specific needs, however, these needs vary over the years and some structures are not frequently used. It has therefore become imperative for architects to rethink their design approach towards solving space problem. Hence, the shift toward space flexibility which if expected to ensure that a building or facility gets used virtually all the time. The benefits of the use of modular principles to achieve flexible spaces include effective use of space, cost effectiveness and reduction of construction waste associated with demolition of sandcrete block wall during remodelling of an existing space into new configurations by end users. According to Giorgio (2005), flexibility in spaces used for pedagogical and didactic activities pose serious challenges in the world today. The use of these spaces for activities constantly changes during the day and for long durations. The need to accommodate various pedagogical and didactic activities in an interior space gave rise to the need for newer avenues for achieving space flexibility such as the modular concept in space planning. The expected outcome of the application of such concepts is the flexible learning space that supports a variety of pedagogical methods and learning experiences. Modular concept in space planning has been in existence for a long time, however it has basically being applied to the construction elements of the building and the location of walls for structural purposes. The use of modular concepts in planning was introduce to improve the flexibility of space to cater for different functions that could make use similar facilities hence reducing the overall running cost and improve sustainability. Modular concept of planning further allows flexibility of space to be achieved because walls and interior components can be assembled and disassembled in new formats to meet the required current user needs (Baldwin and Clark, 2002). A modular system consists of discrete partition elements that are scalable in order to accommodate various sizes and re-useable to serve various functions, while achieving different working environment (Buick & Owens, 2012).

In order to achieve flexibility of spaces in buildings there is always the challenge of merging varied required functions at the predesign and design stage of the building project. The analysis of such design requirements is such that the activities with the larger space requirement are given priority over those with smaller space requirements. The major benefit of modular system is the ease of erecting and time taken to create the required environment. In many building designs in Nigeria of which the skill centres are part of, the spaces are usually specific in nature and not customisable (Adedayo, 2013), and this therefore creates buildings that are usually unusable for other functions when the initial design purpose is

no longer being valid. This study seeks to determine the flexible nature of skill centres with the view of determining functions that could be combined.

The Need for Open and Flexible Spaces in Skills Acquisition Centres

The use of spaces in skills acquisition centres and other centres where pedagogical and didactic activities are carried out are usually functions specific based on the equipment that are used for the training. It becomes a difficulty when the need to accommodate varying changes in utility arises and the safer option usually taken is the construction of a new building to accommodate such utility. According to Young-Ju (2008), the need for flexibility as a new principle of architecture has been on the increase due to rapidly changing social demands of the end users of buildings. Flexibility, variability, openness and transparency are basic requirements that should be placed on skills acquisition centres of the future (Reino, 2002). It further argued that skills acquisition centres should no longer consist of successive rows of classrooms and inter-connecting corridors, but a central and open-learning flexible hall that can accommodate various pedagogical and didactic activities. Spaces in skills acquisition centres are to be constructed with light partitions that are movable instead of load-bearing walls that hinder variability and flexibility (Mark, Ray & Chris, 2014). It implies that if these type of materials are adopted for use in these buildings the issues of flexibility and space demand would be catered for by the Architect.

Skills acquisition centres serve as avenues where students acquire vocational training for economic viability. Various types of skills that can be acquired in a skill training centre according to Gumbari (2009), include vocational skills such as tailoring, carpentry, hair-dressing, fashion designing; technical skills which are skills such as automobile works, mechanical and electrical works; entrepreneurial skills which include skills required to set up small-scale businesses. An examination of the equipment require for these skills vary from each other however they are also related and could be combined.

Properties of Flexible Spaces

Torin (2000), looked into achieving flexible space in traditional education spaces; defined physical flexibility in building as the adjustability of a space in order to suit sensory or mobility needs of the end users. Previous studies (Giorgio, 2005; Corky, 2011; Fowler, 2002 & Haworths, 2009) have shown that flexibility cuts across five basic properties of space which are modifiability, convertibility, scalability, versatility and fluidity they further stated that fluidity of space entails planning a space with adequate thermal and sound insulation. In other words, there must be good flow of air, light and sound in and around the space. Modifiability of space according to Brubaker (1998) involves designing spaces that can be quickly re-configured through the aid of mobile partitions, furniture and equipment. Griffith (2006) described convertibility of space as the possibility of changing the use of a defined space for entirely different uses in

future by the end users. Scalability of space involves designing spaces that can be easily expanded or contracted in proportions. In other words, spaces are increased or decreased by both lengths and widths (Jos, 2010). According to Jos (2010), space versatility allows space to be used for multiple purposes it went further to state that special design considerations are required to allow versatile spaces serve different functions effectively.

Modular Principles in the Design of Spaces

According to Harrison and Hutton (2013), two fundamental modular design guidelines are: functional division of space into scalable and re-sizeable units according to uniform grid system in modules of dimensions divisible by three (3) and the use of flexible and demountable walling units to enclose spaces. Modular sizes are summarized in Table 1.

Table 1: Modular room sizes and movable partitions

S/N	Movable Partitions	Modular/Flexible Lengths/Breadths	Modular/Flexible Room Area (m^2)
1	Sliding Partitions	3.0m,3.6m,4.2m,4.5m, 4.8m, 5.4m, 6.0m, 6.6m, 7.2m, 7.8m, 8.4m, 9.0m, 9.6m, 10.2m, 10.8m, 11.4m, 12.0m, 15.0m, 18.0m.(Multiples of 3 & 6).	9.0m^2, 10.8m^2, 12.6m^2, 12.96m^2, 13.5m^2, 14.4m^2, 15.12m^2, 16.2m^2, 17.28m^2, 17.64m^2, 18.9m^2, 20.16m^2, 20.25m^2, 21.60m^2, 22.68m^2, 24.30m^2, 25.20m^2, 25.92m^2, 27.0m^2, 28.8m^2, 30.24m^2, 34.56m^2, 51.84m^2, 172.8m^2, 180m^2, 270m^2, 360m^2, 540m^2.
2	Folding Partitions	3.0m, 3.6m, 4.2m, 4.5m, 4.8m, 5.4m, 6.0m, 6.6m, 7.2m, 7.8m, 8.4m, 9.0m, 9.6m, 10.2m, 10.8m, 11.4m, 12.0m, 15.0m, 18.0m. (Multiples of 3 & 6).	9.0m^2, 10.8m^2, 12.6m^2, 12.96m^2, 13.5m^2, 14.4m^2, 15.12m^2, 16.2m^2, 17.28m^2, 17.64m^2, 18.9m^2, 20.16m^2, 20.25m^2, 21.60m^2, 22.68m^2, 24.30m^2, 25.20m^2, 25.92m^2, 27.0m^2, 28.8m^2, 30.24m^2, 34.56m^2, 51.84m^2, 172.8m^2, 180m^2, 270m^2, 360m^2, 540m^2.
3	Flexible Partitions	Any room size	Any room size

Source: Harrison and Hutton (2013)

Table 1 summarizes various modular sizes of workshop spaces and different movable partitions that can be used in these spaces. The areas in the last column were derived by multiplying two modular dimension. It is expected that the various movable partitions adhere to pre-fabricated dimensions which are divisible by 3, the

workshop spaces must follow in the same configuration so that the partitions fit into the spaces. According to Baldwin and Clark (2002), modular design grid system in Table 1 must be adhered to at the design stage of skills acquisition centres in order to achieve modular spaces that will be enclosed by the various movable partitions for a flexible space.

Ryan (2011), looked into various types of modular wall systems and their pre-fabricated sizes used to achieve effective division of space with utmost flexibility. The walling systems are demountable and are made up of light weight partitions that are operated in different ways. The infill panels are made up of various materials ranging from glass to aluminium. Discrete wall units used to achieve flexible spaces include sliding partitions, folding partitions and flexible partitions as indicated in Table 2.

Table 2 Types of movable partitions and sizes

S/N	Movable Partitions	Pre-fabricated Sizes (metres)	
		Width (m)	Height (m)
1	Sliding Partitions	0 . 6 0.75 0 . 9 1 . 2 1.25	2.7 (min) 6.0 (max)
2	Folding Partitions	4.5 6.0 7.5 9.0	5.0 (max)
3	Flexible Partitions	Not fixed	5.0 (max)

Source: Ryan (2011)

Table 2 summarizes the various widths and heights of different movable partitions that can be used to enclose spaces. Movable partitions are pre-fabricated in the factory based on the fixed dimensions, however, only flexible partitions can take curvilinear forms because of the nature of operating principle. Flexible partitions comprise a pantographic steel frame, aluminium track systems and a vinyl-coated fabric used to achieve flexible spaces (Ryan 2011). These partitions can be easily expanded by stretching or shrunk by compressing to enclose spaces.

Table 3: Types of walling materials and degree of flexibility

S/N	Walling Types	Degree of Flexibility
1	Concrete Wall	Non-flexible
2	Sandcrete Wall	Non-flexible
3	Curtain Wall	Non-flexible
4	Cavity Wall	Non-flexible
5	Fixed Partition	Partially-flexible
6	Movable Partition	Flexible

Source: Ernst and Neufert (2012)

Table 3 are standards for analysing flexibility of walling materials. The study further looked into various walling types used to enclose spaces and the various degree of flexibility. Movable partitions are flexible because they are designed with operating principle that allow modification and variability with the sizes of spaces they enclose as seen in Plate 1.

Plate I: Sliding partitions enclosing a space. **Source:** Corky (2011).

Plate I shows an interior space enclosed by sliding walls. The operating principle involves a horizontal track system for both ground and ceiling levels. The panels glide freely on the tracks and can be closely stacked to provide adequate sound and thermal insulation. The tracking system and frames are made of aluminium and stainless steel while the panels are made of aluminium composite panels.

Research Methodology

Post Occupancy Evaluation approach was used in undertaking the study using case study method through the use of observation checklist and questionnaire. The use of Post Occupancy Evaluation approach was because the opinions of the respondents regarding the facility were obtained; hence in studies such as this Post-Occupancy Evaluation method, is generally recommended (Adedeji & Fadamiro, 2012; Zimmerman & Martin, 2001). Six selected skills acquisition centres in Benue State were purposively selected out of the twenty-seven 27 available based on the three main types of skills acquisition earlier established and their functionality in terms of current usage. The list of the centre include:

1. Sev-av skills acquisition Vocational centre, Gboko
2. Sev-av skills acquisition Vocational centre, Vandeikya
3. Benue State University Technical College
4. St. Theresa Technical college
5. Sev-av skills acquisition Entrepreneural centre, Makurdi
6. Entrepreneurship Development Centre, Makurdi,

Physical measurements of the buildings used for practical training were taken for spatial analysis. A total of 300 questionnaires were administered to both staff and students of each of the six selected skills acquisition centres in Benue State the breakdown of the distribution is shown in Table 4.

Table 4 Number of responses received

Category	No. of Administered Questionnaire	No. of Returned Questionnaire	Valid Responses
Staff	60	20	15
Students	240	100	70
Total	300	120	85

Descriptive Statistics such as frequency table and cross-tabulation were used to in the analysis of the data. The results are presented as tables and charts which were used to explain the findings of the study. The pictures are presented as plates to provide visual description of the observation.

Results and Discussion

The results presented focussed on the sizes of the spaces within the skill acquisition centres, the modular nature of the spaces and the nature of walling materials used in these centres as they affect the level of flexibility obtainable. The various possibilities of combination of activities to create flexible spaces are also presented, the number of

walls available in these buildings is also essential to determine the flexibility of the spaces.

Physical sizes of Workshops in the Centres

The sizes of the individual spaces in the skill centres affects the type of activities that could be combined when designing for a flexible space provided that all other requirements have been met. It is therefore imperative to determine the larges spaces within the skill centres so as to help show how combinations could be achieved. In addition sizes of the various workshops in the studied skill acquisition centres were examined to determine their level of conformity to modular dimensions. It was observed as presented in Table 5 that the workshops did not conform to modular dimensions as they are not easily divisible by 3. It implies that if modular flexible system is to be deployed for such workshops there would be waste in the provision of such partition materials. It also implies that if modular system is to be deployed the final dimensions after the construction of the building must be ensured to fall within dimensions divisible by 3. This was due to the fact that majority of the material dimensions (tiles, ceiling sheets, doors & wall panels) as often stipulated by architects are modular.

Table 5 Physical sizes of workshops

Skill Acquisition Centres	Workshop/Room Sizes (Areas in M^2) (Centre to Centre									
	Lecture Hall	Tailoring Workshop	Computer Room	Catering Room	Weaving Room	Decoration/ Beads Making Hall	Automobile Workshop	Electronic Workshop	Carpentry Workshop	Metal Workshop
Sev-Av Skill Acquisition Centre Markudi	172.8	51.84	51.84	25.92	27	34.56	0	0	0	0
Sev-Av Skill Acquisition Centre Gboko	0	21.6	25.92	16.2	0	0	0	0	0	0
Sev-Av Skill Acquisition Centre Vandeikya	0	15.12	11.29	15.12	0	15.12	0	0	0	30.24
Entrepreneurship Development Centre Makurdi	1710	0	0	0	0	0	0	0	0	0
St. Joseph Technical College Makurdi	243	0	27	0	0	0	546	270	270	270
Benue State University Technical College Makurdi	243	0	27	0	0	0	360	180	180	180

Table 5 shows that only Benue State University Technical College and St. Theresa Technical College have spaces that meet the requirement for adaption to modular systems for flexibility. This implies that the building could be used for multiple functions as the need might arise. It could also be observed that workshop spaces for technical skill required larger spaces when compared to spaces used for vocational training. This was due to the sizes of the equipment required to be installed, hence the technical workshop spaces offer better opportunities for flexibility.

Ascertaining the Number of Modular spaces

In ascertaining the nature of modular spaces there was need to account for the number of modular spaces and the average area of such spaces. This would help ensure that should there be need for re-alignment of the functions in these centres the modular nature would assist the designs improve their design proposal. Table 6 shows the range of possible modular spaces that could be created in the different skill centres studied, this showed the possibility of combine certain functions in larger spaces by simply portioning the spaces. The smaller the size of the room the less possibility of application of modular systems in partition. Hence, activities can only occur in a relay manner not simultaneously.

Table 6 Detail Number of modular workshops

Skill Acquisition Centres	Number of Modular Workshop/Room Sizes							
	< 9.0	(9.1-19.0)	(19.1-29.0)	(29.1-39.0)	(39.1-49.0)	(49.1-59.0)	> 59.1	Total
Sev-Av Skill Acquisition Centre Markudi	0	0	2	1	0	2	1	**6**
Sev-Av Skill Acquisition Centre Gboko	0	1	2	0	0	0	0	**3**
Sev-Av Skill Acquisition Centre Vandeikya	0	4	0	0	0	0	0	**4**
Entrepreneurship Development Centre Makurdi	0	0	0	0	0	0	12	**12**
St. Joseph Technical College Makurdi	9	0	1	0	0	0	4	**14**
Benue State University Technical College Makurdi	0	0	0	0	0	0	4	**4**
TOTAL	**9**	**5**	**5**	**1**	**0**	**2**	**21**	**43**

In order to understand the modular possibility for the different workshops and rooms in the centres, Table 6 further shows that the various standard of modular sizes grouping is seven. In ascertaining the workshops with modular sizes, it becomes possible to determine which workshops are flexible that could be further partitioned to accommodate other activities. In Table 7 the summary of centre with modular spaces observed in terms of workshops, it is safe to conclude that the workshops are the spaces with the possibility of creation of modular spaces from the overall space.

Table 7. Summary of modular workshops

Skill Acquisition Centres	Number of Modular and Non-modular Workshop/Room Sizes		
	Modular Workshops	Non-modular Workshops	Total
Sev-Av Skill Acquisition Centre Markudi	6	0	**6**
Sev-Av Skill Acquisition Centre Gboko	3	0	**3**
Sev-Av Skill Acquisition Centre Vandeikya	4	1	**5**
Entrepreneurship Development Centre Makurdi	12	0	**12**
St. Joseph Technical College Makurdi	14	0	**14**
Benue State University Technical College Makurdi	4	0	**4**
TOTAL	**43**	**1**	**44**

Table 7 indicates that "Sev-av" skill acquisition centre, Vandeikya has one non-modular workshop which can be attributed to the partitioning of an existing modular space into non-modular size. It therefore implies that if modular spaces are further portioned without the use of flexible materials, there is the high possibility of creating a non-modular space particular when the partitioning is done to cater for an activity with fixed equipment. It was observed that modular spaces offered better opportunities for flexibility. There are basically two determinants of flexible spaces which sizes should be modular and wall types used to enclose modular spaces should be flexible. The flexibility is in terms of the walling that encloses the spaces; examples of such flexible walling are folding walls, sliding walls and demountable walls.

Wall Types in Skill Centre

Table 8 indicates the different types of walls used in the construction of the skill centres the numbers of walls for each workshop were computed based on geometry. It was observed that the spaces provided within the centres were basically rectangular in shape and were bounded with unmoveable walls. This implies that there is restriction on the number of people that could be accommodated within a given space. The most common wall used in these centres are the sandcrete block walls as shown in plate II. Entrepreneurship Development Centre utilized folding partitions which are categorized under movable partitions to divide adjacent lecture rooms. This was used to create modular spaces and also ensured that spaces could be expanded as the need arose without any form of permanent damages. The use of sandcrete blocks reduced the possibility of flexibility across the different centres in the study area and reduce the possibility of maximising spaces.

Table 8 Number of wall types in various workshops.

Skill Acquisition Centres	Wall Types in Various Workshops						
	Concrete Walls	Sancrete Blockwalls	Curtain Walls	Cavity Walls	Fixed Partitions	Movable Partitions	Total
Sev-Av Skill Acquisition Centre Markudi	0	20	00	0	0	0	**20**
Sev-Av Skill Acquisition Centre Gboko	0	11	0	0	0	0	**11**
Sev-Av Skill Acquisition Centre Vandeikya	0	16	0	0	1	0	**17**
Entrepreneurship Development Centre Makurdi	0	32	0	0	0	8	**40**
St. Joseph Technical College Makurdi	0	45	0	0	0	0	**45**
Benue State University Technical College Makurdi	0	14	0	0	0	0	**14**
TOTAL	**0**	**138**	**0**	**0**	**1**	**8**	**147**

Plate II Computer workshop in "Sev-Av" Skill Acquisition Centre, Makurdi.

The issue of flexibility is not just limited to the building alone but also to the users' opinion of such spaces as it enhance their working environment. Hence, need to examine the perception of flexibility in terms satisfaction with the work space provided in the centres.

Determination of Users Perception of Satisfaction with the Sizes of Work Space

The working space is one of the most important active spaces in the skills acquisition centre. An examination of the distribution of the level of satisfaction with the space size by respondents in Figure 1 showed that 70% of the respondents were not satisfied with the size of the spaces provided which could be because they felt the room appeared cramped whenever the number of trainees is high. The walls also gave a sense of rigidity because most demountable materials used in creating flexible spaces usually created some form of confined spaces in an attempt to cater for the trainee population. This could be understood considering the population of trainees and the use of one instructor, hence the need to always split the trainees into different classes did not encourage both staff and trainees.

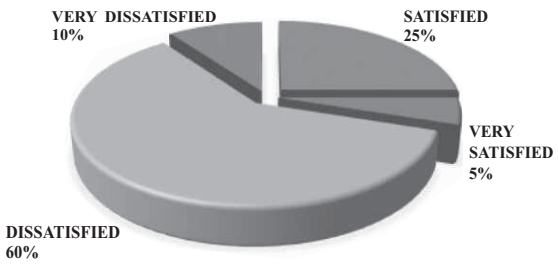

Figure 1 Users' satisfaction with size of working space

It is obvious that trainees in the various workshops are dissatisfied with the

non-flexible working spaces which should have been increased easily to accommodate increasing sizes of the population and space occupied by the machines or furniture. Specific cases such as the computer and entrepreneurial courses are general and compulsory courses taken by all students irrespective of the specialized discipline and definitely require larger spaces. However; the students end up using a congested space which has a relationship with the dissatisfaction with the size of the working space by students of the skills acquisition centres. Spaces are effectively utilized because of the modifiability and versatility nature of flexible spaces while dead or unused spaces are eliminated due to the scalability and convertibility nature of the same flexible space. When this is achieved in a building the level of perception of satisfaction of space is expected to increase.

Conclusion and Recommendations

The study revealed that a high percentage of the working spaces studied were not modular in sizes in the exact required dimensions but could be fitted to serve the purpose of modular systems if flexibility was to be adopted in the training centres. The rigid nature of the buildings reduced the possibility of flexibility particularly in the classrooms and laboratories. It is ideal to use non-flexible sandcrete walls to enclose large spaces that could further be partitioned. It is of utmost importance for architects to meet the two basic determinants of a flexible space as described in the introductory part of the paper in order to achieve flexible spaces in skills acquisition centres.

In other to achieve flexibility of space in skill acquisition centres the following recommendations are therefore necessary: Architects should always ensure that the activity requiring the largest space is given priority and it should form the basis for other multiple functions that would be conducted in the space. It should always be ensured that sub-division of a larger space into a smaller space or vice versa accommodate modular dimensions that are divisible by 3. More so, architects should always ensure that pre-fabricated walling materials with high degree of flexibility such as sliding walls, folding walls or flexible walls are designed to enclose spaces. Finally, Design considerations that support the use of movable partitions to enclose or divide spaces should be adhered to by architects at the design stage.

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