The Application of Spatial Pattern Analysis in High School Level Geography

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Abstract

Geography is a vital subject of the school curriculum which is creative, practical and intellectually stimulating. It tries to identify features on the field, their spatial pattern as well as give explanations to process which have generated the observed distributional patterns their location and provide scientific explanation for the evolution of such patterns. It deals with concepts needed to develop a sharp geographical mind capable of appreciating and solving important spatial problems. This article examines the importance and application of core concepts, nature and observations needed to help students at high school.

Introduction

The inclusion of geography in the school curriculum could be traced back to the inception of western education prior to 1942 (Pafuwa, 1974). Though a key subject of the school curriculum in Nigeria secondary schools, it has been looked at as a teaching and accumulation of facts alone with no emphasis placed on the need to establish correlations and inter relationships among the various geographic variables at different locations.

Geography is a versatile expressive, creative problem solving and practical intellectual stimulating school subject. Learning geography actually implies the learning of certain concepts, principles theories and skills involves in the subject (Okunrotifa, 1973). In the opinion of David Havey (1969), Geography analysis spatial distribution of earthly phenomena and explains variables and association of these phenomena in terms of the process which have generated the observed distributional patterns. Thus, geography basically identifies pattern of spatial variables and attempts to provide scientific explanation for the evolution and implications of the observed spatial patterns.

Geography as an academic discipline, is mainly concerned with the scientific analysis of spatial variables. These spatial variables can be grouped under the followings categories.

i Human population with reference to their numbers and demographic characteristics.

ii Natural phenomena such as topography, drainage, vegetation, soils, elements of weather, natural resources, hazards and

iii Man made features such as transportation networks, settlement patterns, dam construction, farmland etc.

Basic to all spatial variables are the concepts of location, distance distribution interconnection, interaction and areal differentiation which in geographic space constitute a fundamental structure known as the spatial pattern. This paper therefore seeks to clarify the basis concepts of geography at the high school level. However, emphasis on concepts and conceptualization is necessary for a number of reasons which include:

(i) Geography is elevated from discrete particular and description level to scientific level where generalized statement link several phenomena together

(ii) It facilitates intellectual growth and this will help in effective learning.

(iii) It also helps in classification and ordering what other wise proves to be chaotic concepts are more flexible and more permanent than facts. They generalize the particular and this constitutes the basis upon which the mind structures its experiences.

At this junction it is essential to make clear the concepts mentioned above. By definition, location is either absolute or relative (Able 1971, pg 59). Absolute location is a position in relations to a convectional grid designed solely for locative purposes. Latitudes and Longitudes are the most common means of describing absolute location. In this case, the location is fixed and remains as customary and unchanging units such as miles, kilometers or degrees are used to measure distance. Relative location on the other hand is position with respect to other locations. This can be expressed in terms of time or transport cost to move from one location to another. Geography is today mostly concern with the changing nature of space, and as such is primarily concerned with the relative locations of phenomena.

Locations can be at a point, they can be linear or areal. Some features e.g. lakes, towns, cities and ports have point location while features like transport routes, roads, railways lines and rivers have linear locations.

However, individual regions are separate by distance with varying degrees of accessibility. Some locations are more desirable than others for specific human activities. This through a series of agglomerative process, a hierarchical structure of relative locations may become significant in the analysis of population structure, retailing activities and transport networks.

The type and intensity of the linkages between different locations in space determines the nature and degree of interconnection, interaction and association among the various locations. A low degree of interconnection indicates limited interaction and hence loses association while a high degree of inter-connection indicates high level of connection and association among the locations.

Abler et al (1971, pg 56) defines distribution as the frequency with which something occurs in space. Distribution can be in one-two three or N—dimensional space and the underlying notion is similar in all cases.
The nature of all distribution would depend upon the scale at which each is observed. Spatially distributed phenomena may be available every where over the surface of the earth (Ubiquitous) or localized, but the former are rare; areal variation- spatial differences in occurrence and density in characteristics of most distribution in terrestrial space.

The spatial pattern is thus the overall configuration of a set of location in any area with the characteristics linkage, which indicates the level of interaction, interconnection and association among these locations. The spatial patterns of any phenomena at a given point in time results from compromise of dynamic process involving diffusion promoting forces on the one hand and the barriers, the contracting and up rooting forces on the other. In other words, spatial patterns manifest the extend to which spreading forces over power the counterforces.

Operationalisation Concept
It is clear that the meaningful analysis of the spatial pattern of geographic variables must necessarily involve precise measurement of the component concepts discussed earlier above. We can use various aspects of geography to illustrate these concepts. For example we can take a college compound as a spatial system with the various building in it constituting the locations. We can guide students to measure the distances between pairs of adjacent classrooms or event the trees found within the compound. In particular the students should determine the distances between their Hall of residence and classrooms, and spatial buildings like the Dinning Hall, principal's office, science labs, library etc

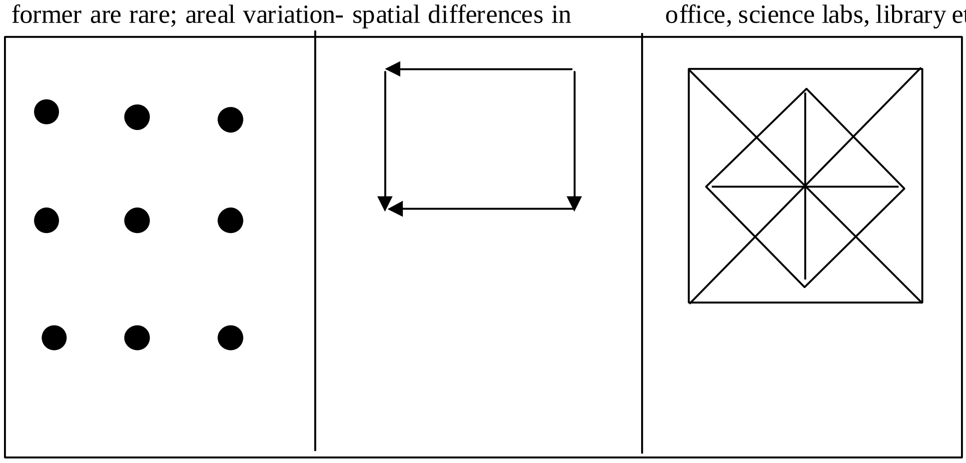
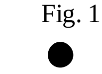
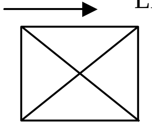


Fig. 1 Locational patterns



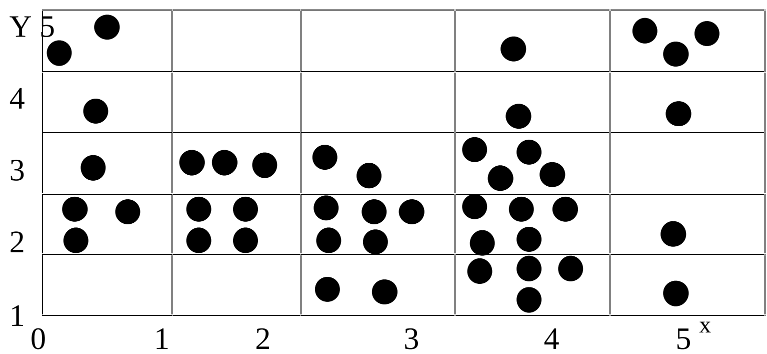
Point locations e.g. town, cities
Linear location e.g. roads, river, railines etc.



Areal locations e.g. regions, countries, states, LGA, etc.

Example I. Let us considered the following distribution

Northings



Eastings

To start with, the distances to be measured, should be in the same units, e.g. kilometers, meters, miles or feet. Rather the students can be able to measure in terms of the time taken to walk from one location (building) to another. A map of the college compound will reveal the distributional pattern of the buildings or locations. Then when the index of interaction is potted, a spatial pattern would emerge very Clearly showing areal differentiation. The spatial distribution can be measured using any of the three methods:

i Central tendancy and dispersion
ii Chi- squared test (X^2) and
iii Nearest neigbour analysis.

We can measure the central tendancy dispersion to analyses spatial distribution. This can be easily done by superimposing grid lines and describing their location using the grid reference. This is a measure of central tendancy within a spatial distribution and is defined accurately by means of two co-ordinate (X, Y) representing the distance of that point horizontally and vertically from a fixed reference point as shown below.

For the above distribution it would obviously be possible to list the x and y co- ordinates of the points shown quite accurately and to calculate their separate means in the normal way. But it is easier to considered the data in grouped from using the existing grid line as class boundaries.

We thus have to count the number of points lying firstly between nothing as the results tabulated below.

Table 1: Number of points lying firstly between nothing

	Easting					Northing
	f	d	fd	F	d	fd
0-0.9	4	-3	-12	7	-2	-14
0.9-.9	5	-2	-10	14	-1	-14
1.9-2.9	9	-1	-9	12	0	0
2.9-3.9	15	0	0	+2	+1	+2
3.9-4.9	7	+1	+7	+5	+2	+10
	40		-24	40		-16

This enables approximate values for the co ordinate of the means center to be worked out as shown below.

$$\bar{X} = x + \frac{Efd}{n}$$

$$= 3.5 - \frac{24}{40}$$

$$= 3.5 - .6$$

$$\bar{x} = 2.9$$

$$\bar{y} = y + efd$$

$$= 2.5 - 0.4$$

$$\bar{y} = 2.1$$

Thus the approximate co ordinates of the mean center are (2.9 2.1) and this point can be located on the map or distribution as shown in the above distribution.

The Chi-squared ($x^{2)}$ method of analysis can be applied (Davis 1974 pp.29-33).

In this case we are trying to compare the existing distribution with some kind of expected distribution i.e. expected
and observed distribution.

$$X^2 = Ó \quad \frac{E}{(O-E)^2}$$

Where O., is the observed and E., is the expected distribution.

The following procedures applied:

i count the number of points in the pattern under consideration. In the distribution above is 100 points

ii construct grids of squares of equal of size to cover the study area completely as above.

iii calculate the expected frequency of points in each grid square working on the assumption that the pattern is perfectly ordered.

$$\text{Expected frequency (E)} = \frac{\text{Total no. of points}}{\text{No. of grid squared}}$$

iv count the number of points actually located within each grid square and record each total as an observed (o) frequency.

v calculate the value of X^2 using the formula

$$X^2 = Ó \frac{(O-E)}{E}$$

Let us assume that the following diagram represents spatial distribution.

Figure 2: Spatial distribution

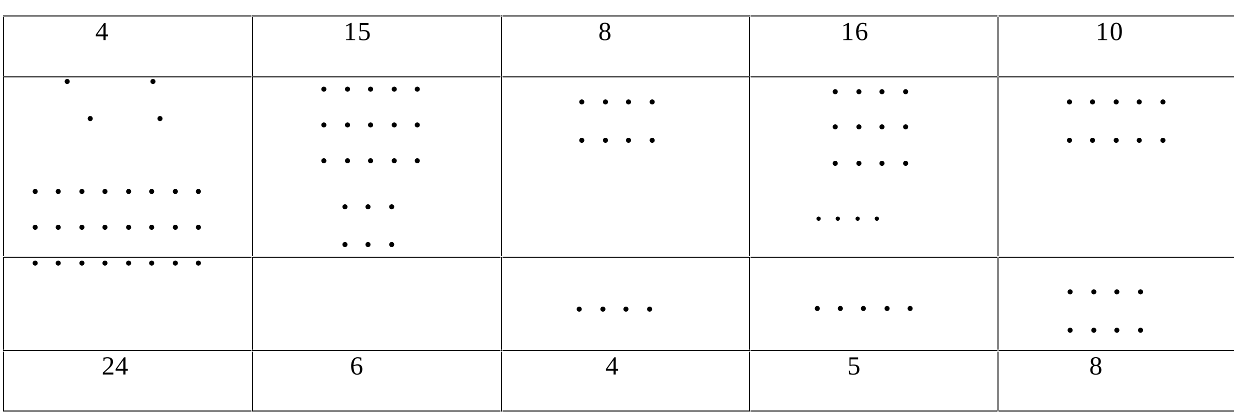


Table 3 : Observed and expected frequency for each square

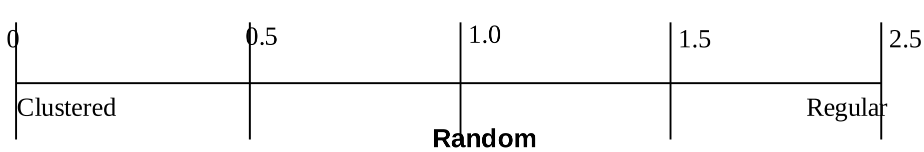
O	E	O-E	$(O=E)^2$	$(O-E^2$
4	10	-6	36	3.6
15	10	5	25	2.5
8	10	-2	4	0.4
16	10	-16	56	25.6
10	10	0	0	0
24	10	14	196	19.6
6	10	-4	16	1.6
4	10	-6	36	3.6
5	10	-5	25	2.5
10	10	-2	4	0.4
		X^2	$\frac{(O-E)^2}{E}$	59.8

The distribution, the observed and expected frequency for each square can be tabulated as shown in table 3. If the pattern were perfectly ordered then clearly $X^2 = 0$ since the expected and observed frequencies are identical. But in this very example, value of X^2 is quite high (i.e. 59.8) and as such it suggest a greater degree of clustering. The nearest neighbourhood analysis method can be also be applied (David, 1974). This can be done by finding the average distance between all pairs of nearest neighbours. This can be calculated by comparing the observed mean distance and the expected mean distance.

$$Rn = \frac{\overline{do}}{de} \text{ Or } Rn = 2\,\overline{do}\sqrt{\frac{n}{A}}$$

Where Rn is the nearest neighbour index, do observed mean distance, de expected mean distance, n, number of points and "A" area. If the pattern is random, the Rn value will be one (Rn = 1, if Rn is less than one (Rn 1), it means that points under analysis are closer in space than shown in random distribution, therefore tending toward clustered pattern. If Rn exceeds one (Rn 1), this mean that the pattern is tending towards uniform distribution as observed distance is greater than expected. Thus a surrogate scale for measuring spatial patterns has been devised. The scale starts at zero which indicates complete agglomeration, moving through 1.00 random pattern to 2.15 ideal or normative hexagonal lattice.

At the higher level of observation, we may be consider a rural community in which villages and farm-stead constitute the point of locations while foot paths and roads provide inter village linkages. The degree of connectivity is considered to be of considerable significance in the analysis of network geography especially as there may be significant relationship between connectivity and degree of development a region or country has attained. Kanskey provided a number of indices which can be used for the purpose. Two of the simplest yet most useful ones are the beta (B) and gamma ® connectivity ratios (Davis, 1974).



Surrogate scale

These can be calculated as follows

number of routes

Beta index = â = ____________________

Ç(number of nodes – 2)

This is designed so that any network with â index less than 1.0 will be composed largely of branches, while a ratio of exactly 1.0 indicates the presence of one complete Circuit. A ratio of over 1.0 indicates the presence of more than one complete circuit i.e. increasing connectivity.

Gamma index (ã) = $\frac{\text{number of routes}}{\text{Ç(number of nodes -2}}$

In this case the connectivity index always lies between 0/0 for a null graph or connectivity and 1.0 for a complete graph or connectivity.

Example of working â and ã are shown below:

â = $\frac{\text{number of routes}}{\text{number of nodes}}$

$$= \frac{18}{11} = 1.6$$

$$y = \frac{\text{number of routes}}{3(\text{number of routes} - 2)}$$

$$= \frac{18}{3(11-2)} = \frac{18}{27} = 0.66$$

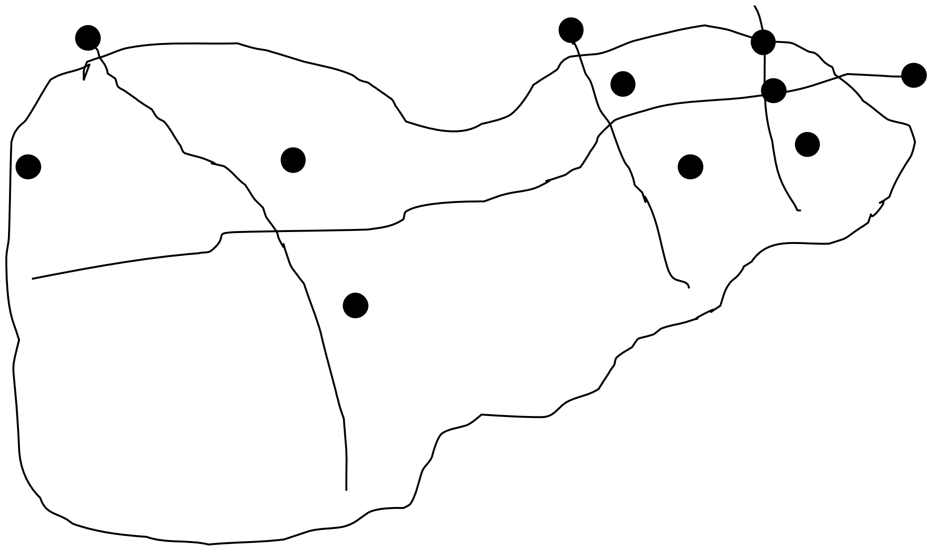


Figure 3: Connectivity

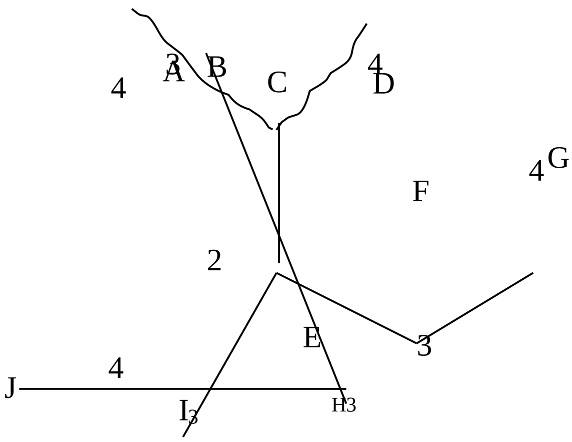


Figure 4: Network node

The degree of centrality of any point on the network may be describe by its Koing number (Davis, 1974). For each nodes this is given by the maximum number of areas to any other node by the shortest paths available. The konig number is given for each node as indicated in the example provided in figure 4

In the above, node E has the lowest koning number as 2, and as such, it is the most central node. One of the important aspect of network analysis is the measurement of accessibility of nodes. The use of route matrix, where the presence of a l a o, represents the presence or absence of a direct link between two points can also give some idea of the accessibility of each node by totalling the row in such a matrix. The nodes with the highest number of links as shown in the row totals may be considered to be those with the greatest degree of accessibility (see fig 5). In this example the most accessible node is E with a value or total of 4

Interaction – movement between places of places people, places of people, goods and services and information does not occur in isolation but is stimulated by particular forces. Edward L. Wilman (1956) postulate three conditions for interaction

(i) Complementarily
(ii) Intervening opportunities
(iii) Transferability (Abler R. et al 1976; P. Bloyd and Dickin, 1972).

For two places to interact there must be a demand – supply relationship between them – not just mere areal differentiations as traditional assumed.

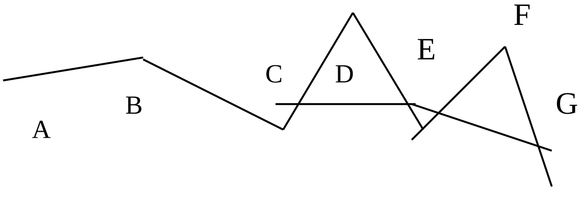
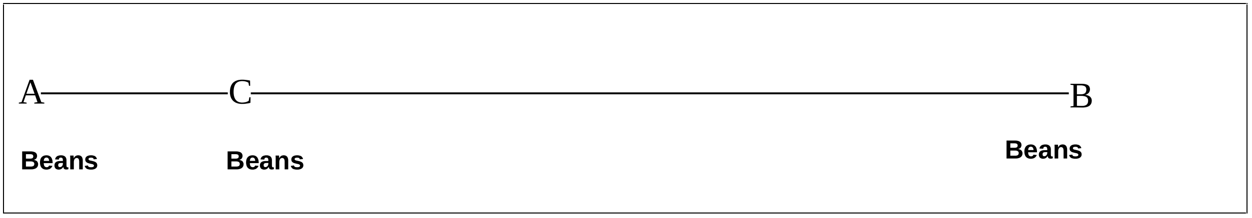


Figure 5 Road network

Table 4: Route matrix

TC	A	B	C	D	E	F	G	TOTAL
A	0	1	0	0	0	0	0	1
B	1	0	1	0	0	0	0	2
C	0	1	0	1	1	0	0	3
D	0	0	1	0	1	0	0	2
E	0	0	1	1	0	1	1	4
F	0	0	0	0	1	0	1	2
G	0	0	0	0	1	1	0	2



One place must want what the other place has got (effective demand of course) and the letter must be willing or prepared supply it. Complementarily is so significant as a basis for spatial interaction that many very low value bulk commodities can move many thousands of kilometre if complementarily conditions are properly met. It should be noted, however that there will be interaction between two locations say location A and B if there is no intermediate or alternative source of supply i.e. intervening opportunities. Once there is an alternative source of supply in a nearby a town Or city, the complementarily relationship which exist between that town and a distant one will be negated for the nearer supply sources.

Deficit surplus surplus

For example, one, respect in which center A and B are complimentarily is that B provides beans while A does not. Thus, there is a demand at A for center B to provides beans. However, this complementarily relationship may be negated, if as shown above, there is an alternative source of beans nearer to A at town C. Town A will obtain beans from the closer town C rather than from B which is further away. Another example is Zaria which stands between Kaduna and Soba. Intersection between Kaduna and Soba is more or less absorbed by Zaria which serves both as an origin and destinations for certain goods and services going to and coming from Soba and Kaduna.

Besides complementarily and intervening opportunities, transferability which is defined as the friction of distance also exert great influence on spatial interaction. Transferability is measured in real time and money costs, if money cost or time of traveling a distances are too excessive or long, the movement will be reduced or even not take place despite perfect complementarily and the absence of intervening opportunities.Transferability is also affected by accessibility and political relations. Between countries which will create transport difficulties and absence of interaction.

Despite the above conditions however for interaction, one should also take into consideration the factors of human perception of situations which can play a leading role for interaction between places. Sometimes despite that there maybe an intervening opportunity, a person from one end will ignore the intervening opportunity and go beyond it to satisfy his needs.

$$= f \frac{pa.pb}{f(Dab)}$$

The flow of people, goods and services from one location (town) to another provides an indicator of the level of interaction which may be defined as I ab where ab is the interaction index of location a and b, pa ard the population of two location or towns, Dab, the Distance between town a and. But in practice pa and pb may refer to the number of people who actually interact between the two places.

Further illustration can be made about the concept by extending our reasoning to a country and focus on urban centers, states capitals and even local government headquarters. Here towns can be ordered on the basis of the volume of goods and services they can offer to surrounding regions or other places in the system. This is the rationale behind the central place theory whereby a higher order center performs both higher functions and also those functions performed by lower center places (see figure. 6).

For example in Nigeria Lagos may be regarded or seen as the highest order center providing the widest range of goods and services to many other places. Next to Lagos are some of the oldest state capitals like Port Harcourt, Ibadan, Kano, Kaduna, Benin and Enugu. Lower order are the new state capitals like Katsina, Lokoja, Jalingo, Yobe, Asaba, Gombe, Kebbi, Abakiliki and Uyo.

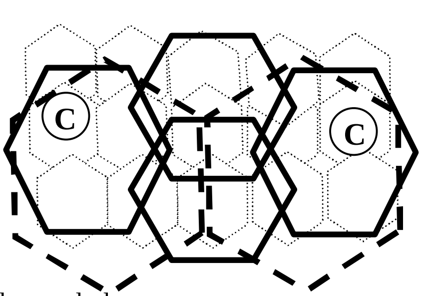
Even at the state level, we can still take state capitals as the highest order center providing the widest range of goods and services to other parts of the state, next to the states comes the local government headquarters while the villages area headquarters can be taken as lower order centers providing goods and services

Need For Supervision And Guidance

The Primarily responsibility of a geography teacher, especially at the high school level should be to provide the link between his students, their natural and human environments. The students should be made to understand their environment in its proper perspective.

As a result of this, the main purpose of teaching geography at the high school level (should be the development in students of (i) visual memory and imagination necessary to form appropriate images and impressions of objects, places, regions and the world at large (ii) the power of observation, and (iii) judgment and reasoning which are essential for discriminating facts from non facts and opinion, and mentally recording them (Majasan, 1969).

The students should also be helped to analyse, compare and classify geographic objects and facts relating to specific locations in order to awaken in him a sense of relationship and connection which will enable him to formulate and answer questions relating to "why" and "how" of things rather than "where" alone. At this level students should be guided to identify correlations between geographic variables and where possible establish simple causal relationships. They should recognize much of the factors (natural and human) which the spatial distribution of geographic elements are and account for their areal variations. Students should also be guided to develop keen geographic out look which will enable them to gain an overall view of spatial organization by grasping the relationship between various phenomena. The teacher can achieve the above objectives through the adoption of students oriented discussions. This method will give an ample opportunity for the students to participate actively in the lesson instead of a situation where the teacher does most of the talking. The information content has been over emphasized. Emphasis should be actually shifted to deriving concepts from content matter and drawing generalization from particular cases by students.



------- © High level central places.

_____ © Intermediate level central places.

……… .Low level central places

Fig. 5: A hierarchical spatial arrangement of central places.

The teacher should endeavor each year to bring out clearly the importance of the various fundamental concepts in the understanding of the spatial system as may be included in the syllables. For this to succeed, the teacher must as a matter fact must certain conditions which include:

(i) Clarify the purpose of each lesson and make the presentation of his materials interesting. This is to ensure students concentration and participation in the lesson. A geography lesson can be made interesting by adequate and careful planning of the lesson, use of illustrations, skilful presentation of the subject matter and involving students into the lesson by well- planned activity and exercises.

(ii) Provision should be made for student's participation in the lesson. The feeding of students by the teacher should be discouraged.

(iii) The use of assignments as a means of evaluating students progress should be encouraged as it helps to develop ability to work independently thereby making them create interest in the subject.

Conclusion

The high school geography teachers must realise that students are no longer required to accumulate facts alone. They are rather expected to established correlation and interrelationships among various geographic variables at different location.

As such teachers should always start lessons by making clear to their students the basic geographical concepts like location, distances, distribution, Association, interaction and spatial pattern. They should also show the students what is meant by terms such as description, analysis, explanation and models. Knitting together of these concepts will help to develop a sharp geographical mind, which is capable of appreciating and solving important spatial problems.

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