Second United Nations World Geospatial Information Congress

Theme: **"Geo-Enabling the Global Village: No one should be left behind"**

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TP4A - Capability Development for Sustainability and Resilience

Towards Democratizing Geospatial Information Systems Education - the Case of Andhra Pradesh

Flow

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2. Introduction
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4. Linkages with Information Technology
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1. Definitions

• A "Geographic Information System (GIS)", or some times referred to as a geospatial information system is a computer system for storing, analyzing, and displaying geographic data and associated attributes which are spatially referenced to the earth.

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• From a mathematical perspective, GIS provides a method to mark events occurring on the Earth's space and time dimensions, with longitude(x), latitude(y), and elevation(z).

• Thus, Earth-based, spatial–temporal, location and extent references are relatable to one another, and ultimately, to a "real" physical location by GIS

• Research studies show that educators and students who apply spatial thinking to real-world issues at a range of scale through GIS are efficient spatial thinkers.

• "Democratization of Education" in the strict sense is the interaction of four components:
1. Democratization of pedagogic forms, methods, and activities
2. Democratization of content, with attention to include world experience, individual peculiarities, and integration of subjects taught
3. Humanization of educational establishments
4. the democratization of the interactions of education with economy, science, culture, media, state bodies
• In this present discourse, emphasis is on the **first and the fourth component**

2. Introduction

•Research studies show that the adoption of GIS in high school education varies among and within countries, and is intimately connected to the status of the geography course;

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•The various stages of the adoption of GIS in high school and secondary schools globally are highlighted below:
1. Stage 1: (late 1970 – early 1990's): Emergence of the first GIS training programs in the leading universities of the United States and Canada, and partnership agreements between schools and universities of these countries;
2. Stage 2: (mid-1990s – beginning of the 21st century): Dissemination of GIS educational programs in schools of the most developed countries of Europe (France, Germany, Great Britain) and Australia, and the active participation of leading GIS developers packages (ESRI, Intergraph, MapInfo Corp.) in GIS education at all levels;
3. Stage 3: (2005–2012): Spread of the GIS school education in Eastern Europe, Asia, Africa and Latin America;
4. Stage 4: (from 2012 -) : Appearance of GIS in school curricula of most countries.

• World Scenario: Evidence suggests that countries do incorporate GIS into their Geography curriculums of secondary education since 2001-, but the implementation in the classroom is still scarce

• Indian Scenario:
   • GIS is still at a nascent stage in terms of the overall curriculum at the secondary school level
   • Some standardization in the core Geography curriculum in the Central Board of Secondary Education (11th and 12th standard) is evident
   • The role of GIS is limited in pedagogy due to the complexity and cost of GIS software, and lack of trained faculty

3. The Constraint of Mathematics

•The Geography course is a "compulsory" subject, but under the "Arts" stream in the Indian CBSE Class 11th and 12th standard, which implies that the focus of teaching is theoretical, and lacking mathematical rigor

   •The syllabus of CBSE Class 10th Mathematics is shown below:

Units	Unit Name	Marks
I	NUMBER SYSTEMS	06
II	ALGEBRA	20
III	COORDINATE GEOMETRY	06
IV	GEOMETRY	15
V	TRIGONOMETRY	12
VI	MENSURATION	10
VII	STATISTICS & PROBABILITY	11
	Total	**80**

•This syllabus provides an elementary exposure to:
   •Trigonometric ratios of an acute angle of a right-angled triangle,
   •Proof and applications of the identity $\sin^2 A + \cos^2 A = 1$, and
   •Simple problems on heights and distances. not involving more than two right triangles, with angles of elevation and depression at only 30°, 45°, and 60°

3. The Constraint of Mathematics …

•The syllabus of CBSE Class 11th standard is shown below:

Part/Unit	Topic or Chapter	Marks
Part A	**Fundamentals of Physical Geography**	**35**
Unit 1	Geography as a discipline	
Unit 2	The Earth	
Unit 3	Landforms	
Unit 4	Climate	
Unit 5	Water (Oceans)	
Unit 6	Life on the Earth	
	Map and Diagram	5
Part B	**India - Physical Environment**	**35**
Unit 7	Introduction	
Unit 8	Physiography	
Unit 9	Climate and Natural Vegetation	
Unit 10	Natural hazards and disasters	
	Map and Diagram	5
Part C	**Practical Work**	**30**
Unit 1	Fundamentals of Maps	15
Unit 2	Topographic Maps	10

3. The Constraint of Mathematics ...

•The syllabus of CBSE Class 12th standard is shown below:

Part	Units	No. of Periods	Marks
A	**Fundamentals of Human Geography**	90	35 Marks
	Unit 1: Human Geography	07	30
	Unit 2: People	20	
	Unit 3: Human Activities	32	
	Unit 4: Transport, Communication and Trade	26	
	Map Work	05	5
B	**India: People and Economy**	90	35 Marks
	Unit 6: People	15	30
	Unit 7: Human Settlements	10	
	Unit 8: Resources and Development	30	
	Unit 9: Transport, Communication and International Trade	15	
	Unit 10: Geographical Perspective on selected issues and problems	15	
	Map Work	05	5
	Total	**180**	**70 Marks**
C	**Practical Work in Geography Part II**	40	30 Marks
	Unit 1: Processing of Data and Thematic Mapping	25	**15**
	Unit 2: Spatial Information Technology	15	**10**

3. The Constraint of Mathematics …

Some inferences: .

1. Students studying Geography in CBSE Class 11 and 12, do not have exposure to Mathematics, since Geography is offered in the "Arts" stream.
2. In the two year curriculum, the above students are exposed about 15 hours to "Spatial Information Technology".
3. A similar situation exists as noted above in the several State Boards of Education.
4. Though GIS was recognized as an aid to the Geography discipline in the classrooms in the past, there is no statistical evidence to show the scope of GIS in the schools and college educational curriculums in the State.
5. Take the fundamental GIS application of finding the distance between two places, given their latitudes and longitudes:
    - In flat surfaces, we calculate distances between points by using the norm of the vectors that represent the two points.
    - But the earth is ellipsoid, and not flat!!

3. The Constraint of Mathematics ...

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• Haversine Distance is a mathematical way to calculate distance between 2 cities given the latitude and longitude coordinate of each city. Since Haversine Distance uses latitude and longitude, it already takes into account the spherical aspect of the earth.

• Central angle Haversine can be computed, between two points with **r** as radius of earth, **d** as the distance between two points, Φ1, Φ2 is **latitude** of two points and is λ1, λ2 **longitude** of two points respectively, as:

$$\Theta = \frac{d}{r}$$

$$\text{haversin}\left(\frac{d}{r}\right) = \text{haversin}(\phi_2 - \phi_1) + \cos(\phi_1)\cos(\phi_2)\,\text{haversin}(\lambda_2 - \lambda_1)$$

3. The Constraint of Mathematics …

Notice the following important properties of haversine trigonometric ratio:

hav(0∘)=0   hav(180∘)=1   hav(−θ)=hav(θ)   hav(θ)=sin**2 (θ/2);

Using these properties, the haversine formula can be simplified to:

$\cos(c)=\sin(\varphi 1)\sin(\varphi 2)+\cos(\varphi 1)\cos(\varphi 2)\cos(\lambda 2-\lambda 1)$ ----------------------------(1)

For example, suppose we are sailing on a great-circle course from St. George, Bermuda (32°20'N, 64°40'W) to Horta in the Azores (38°30'N, 28°38'W) and we need to calculate the distance along this track:

$(\varphi 1,\lambda 1)=(32\circ 20',-64\circ 40')$

$(\varphi 2,\lambda 2)=(38\circ 30',-28\circ 38')$

$\varphi 2-\varphi 1=6\circ 10'$ $\varphi 2+\varphi 1=70\circ 50'$ $\lambda 2-\lambda 1=36\circ 02'$

$\cos(c)=\sin(32\circ 20')\sin(38\circ 30')+\cos(32\circ 20')\cos(38\circ 30')\cos(36\circ 02')$, or

$\cos(c)=0.3329482+0.5347487$, or

$\cos(c)=0.86769696$, or

c =29∘48.5'=(29∘)(60'1∘)+48.5' (converting to minutes using 1 degree = 60 minutes), or

c=1788.5' = 1788.5 nautical miles = 3312kilometers. (1 Nautical Mile = 1.852 Kilometers)

Similar mathematical complexities are involved in the studies of vector datasets

4. Linkages with Information Technology (IT)

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• Students studying Geography under the "Arts" stream would continue their studies in the Bachelors Degree in Arts

• It may thus not possible for a present-day student studying in the CBSE 11th and 12th standard to understand the "under-the-hood" workings of GIS in view of the mathematical complexities involved in the GIS concepts

• Though GIS was recognized as an aid to the Geography discipline in the classrooms in the past, there is no statistical evidence to show the scope of GIS in the schools and college educational curriculums in the State.

• Since the emergence of the internet, and the advances in Information Technology (IT), a new pedagogic dimension has been added to the Geography discipline.

• Teaching GIS through an IT lens would attract students from the science and mathematics streams, which helps raise more research questions.

4. Linkages with Information Technology (IT)

- This proposal makes a case for teaching GIS to the Class 11 and 12 students of the CBSE and the State Board in the science and mathematics stream through the open-source QGIS software (see https://www.qgis.org/en/site/)
  - These students are already taught to write computer programs in Python and MySQL (Structured Query Language) as a part of the "Computer Science" subject
  - Since QGIS plugins are written in Python, and interface with the MySQL database, an exposure to QGIS for 30 teaching hours to the students would motivate IT-driven spatial thinking
  - Suggested topics are
    1. Creating maps,
    2. Creating shape-files,
    3. Vector and raster data,
    4. Data visualization – Styling vector layers, Styling raster layers, and
    5. Spatial analysis – Combining raster and vector data.

5. Expected Impacts

1. The GIS has been adopted by the Government of Andhra Pradesh, and its agencies to scientifically manage socioeconomic development in departments like agriculture, fire, forests and environment, industries, land and revenue, irrigation, and school through a plethora of interactive GIS mapping tools and software.

2. Propagating the study of GIS through an IT perspective, the QGIS, through course curriculum in pre-university education in the highly popular "Science" stream as suggested above would drive more curiosity in citizen e-service centers (popularly called as "Grama and Ward Sachivalyams" in the State), which also doubles up as "Digital libraries" to the citizens.

3. The "Digital Libraries" are expected to be used by both the citizens and the students at the grassroot levels; This may drive QGIS applications usage, and help generate local geospatial data with more accurate ground truthing.

4. From a long term perspective, the research and innovation outcomes in GIS applications may be more impactful, with the infusion of students from the science and mathematics stream.

End of session

Thanks