WEB ATLAS VERSUS HARD-COPY ATLAS – READING AND COMPREHENSION OF CARTOGRAPHIC INFORMATION

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INTRODUCTION

Virtual course named 'Maps and Mapping'[1] teaches basic cartography, and one of its chapters is called 'space and prototype maps' (ch. 2). It deals with acquaintance, reading, data acquisition and knowledge obtaining from prototype maps, such as: geological maps (sedimentary, structural), 3d maps (topographical-contours, shaded), and urban maps (land use, geo-statistical). While getting acquainted with these prototype maps, either in web-atlases[2] or in hard copy atlases[3], many students complain that it is difficult to retrieve data from web-atlases. These complaints raise several questions: How do we teach students to dismantle a complex map to its components, in order to retrieve data or information? What are the main attributes/ characteristics should a map contain? What are the essential components of a map, designed to be an informative distributor, not just a sketch?
The Web is a huge content knowledge distributor, maps/atlases producer, and information provider, which defines the components of our knowledge-based society. It is an interlinked, complex and accessible network and its rapid development is constantly and profoundly affecting the way people use information, communicate and learn. The web's impact as a distributor of maps is remarkable. It is especially powerful in dissemination of popular, interactive, clickable and updated maps, which are open to change by the users - like travel and tourist maps. Should the web be the educator to how maps should be produced, read and understood?

RESEARCH QUESTIONS

Both the students' complaint and the maps' quick distribution by the web raised the following research questions:

1. Are there any differences between maps presented in web atlases and those designed in hard-copy atlases?
2. How do these differences, if there are any, affect reading, comprehension and extraction of information from these atlases?

THE CONCEPTUAL FRAMEWORK

In order to examine and/or to compare the 2 types of atlases, a conceptual framework of the maps' characteristics was designed. This framework consists of 3 main notions: **cartographic, geographic and formal characteristics**, all examined in two different periods of thought: the years 60's-70's of the 20th century and the 80's-90's. The recent period of the 21st century will be discussed separately as a conclusion:

a. **Cartographic characteristics**, meaning graphic illustration representing observed reality, Perception and Design of Graphic Representation. This notion refers to all typical cartographic attributes, which are displayed in the margin of almost all atlases/maps published in known series.
b. **Geographic characteristics**, meaning graphic illustration representing Geo-Spatial Conception, Perception and Design of Geographic Representation.

Formal language, meaning graphic illustration as a communication device and dynamic sources material. It raises awareness to the communication process through the web, and the language by which data is transferred from the map's editor to the map's audience/consumer. This last concept focuses on the dynamic components of the data transformation such as interactivity, visualization, reading, comprehension and achievable extraction of information.

[1] **Maps and Mapping**, http://virtual.tau.ac.il/Default.asp?time=1005808516743 – The virtual campus of Tel-Aviv University, ch. 2, Spaces and prototype maps
[2] World general atlas http://www.lib.utexas.edu/maps/middle_east_and_asia/middle_east_ref_2002.jpg common, general atlas; http://earthquake.usgs.gov/recenteqsww/ topical/geological atlas
Brawer M. [Ed]. (1995): **The New Israeli University Atlas**, (in Hebrew), Y. Orenstein "Yavneh" Publishing House, Ltd. Tel-Aviv, Israel pp. 26-43; http://www.lib.utexas.edu/maps/middle_east.html 1973

The students in the course were divided into groups. Each group chose one subject-matter, which was published in a series of prototype maps and provided in professional websites, like floods, urban, political-national or relief. Each series of topical–prototype maps was analyzed in both formats: hard copy and web atlas. The assessment was based on the conceptual framework mentioned. The comparison of the two types of atlases is described in the following chapter, and will be illustrated using the topical earthquake maps of the Middle East.

The enclosed paper will focus on the second part of the framework (b).

B. Graphic illustration representing Geo-Spatial Conception
Many changes occurred during the process of transferring maps from the conventional hardcopy atlas to the dynamic web atlas. These changes aren't merely technical improvements, but are conceptual and perceptual changes. The conception of the Geographical Space moved from the zonal, regional and physical concept, into the spatial, environmental and human organization theory. In the early 20th century, the Geographical Space was considered to be a concrete space, or a model of terrestrial surface in terms of earth, natural regions/ zones4. However, by the end of the century, the Geographical Space was looked at as an abstraction of reality, or a model expressing geo-spatial organization between environmental/ human phenomena5. The representations of these spaces were designed accordingly. While the hard copy atlas presents the regional area, the web atlas displays the spatial/functional thought. These conceptions have different attitudes in their geographical representations and cartographical illustrations.

B.1 The Geographical Space of the Middle-East and its regions/zones, are presented in the hardcopy atlas as a Concrete Physical Space, expressed in conventional graphic symbols (like colors scale, shaded relief). The cartographic design emphasized the 3d geographical forms (like heights, gradients, features, schemes and outlines). A model of Terrestrial Surface was the main idea. It influenced the tools and efforts invested in expressing an accurate, measurable model of 3d relief and the natural zones (figure 1: a).

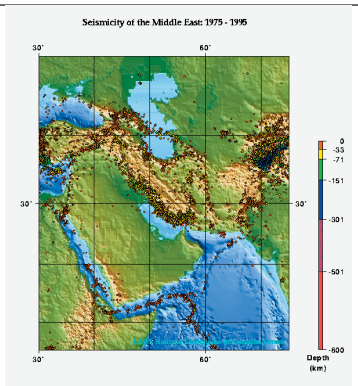
a. Measurable Concrete Space, 3d shaded relief, closed and definite scale.	**b. Abstractions** of Reality, model expresses geological events spatial organization- earthquakes and their interaction with human phenomena, The Seismicity of the Middle East: 1975-1995
	
http://www.lib.utexas.edu/maps/middle_east_and_asia/red_sea_87.jpg	http://neic.usgs.gov/neis/general/seismicity/m_east.html

Figure 1: **Geographical Space** - Conception, Perception and Design of Geographic Representation

The Middle-East zones presented in the web atlas, focus on Abstractions of Reality (like size, shape, and value of a phenomenon). A model of the 3d Thematical, geo-statistical reality/surface is designed (like seismicity: history or current).

[4] http://www.lib.utexas.edu/maps/middle_east.html ; http://www.lib.utexas.edu/maps/middle_east_and_asia/
[5] http://www.usgs.gov/science/ ; http://geology.usgs.gov/ ; http://earthquake.usgs.gov/ ; http://earthquake.usgs.gov/recenteqsww/Maps/ortho/90_0.html

This reality/surface is expressed in different presentations of graphic symbols (like colored, sized and shaped geometrical symbols). The main effort is to present an abstractive, geo-spatial organization of space (i.e. event, cost, time). The realistic 'photo' of the physical landscape is replaced with the image/simulation of human interactivities, landscapes and configurations. This space is no longer static but dynamic, which requires up to date and real-time information, which can be obtained with clickable, interactive maps. Moreover, these valuable characteristics of data and its mapping need interactive, rapid assessment and notification of any event, with backup fact-sheets (see figure 1: b).

B.2 The **Geographical Theme** of the Middle-East and its **Subject-Matter**, are presented in the hardcopy atlas through its physical components: geology and geomorphology hydrology, climatology, performed in prototype, traditional mapping. Even though most of these maps are dated to the early 70, their data and mapping did not change since the beginning of the 20th century. The themes or the subject-matter are closed to any current modification because of the high expenses in new data acquisition, designing, processing and producing new hard copy printing plates. Their generalized data were accumulated for the last 50 years or more (figure 2: a).
In the web atlas, the Geographical Theme of the Middle-East and its Subject-Matter, are human components of population's dispersal and distribution in space: factual (earthquake)[6], political and historical processes (boundaries, seismicity)[7], urban (growth) and industrial (innovation). They were designed in different prototype, thematical and conventional maps. For example, a click on one of the states in the political reference map, will link to a fact book/ database including: textual[8], graphical, numerical[9] and other information regarding the specific state (figure 2: c, d). Moreover, a click on a world seismicity map, will link to various continental maps, lead to a region, continue to a state, and end pinpointing to the epicenter of an earthquake (figure 5: all).

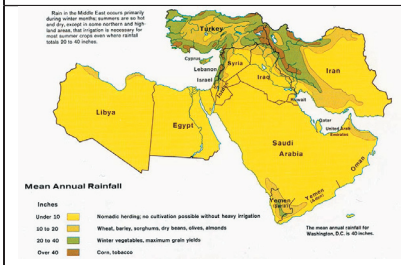
a. climatologically presentation **Mean annual rainfall**, closed to any current modification	b. Size, components dispersal & **distribution of population's** phenomena in space; political process in space. **Middle east political map**	c. **Iran 2005**
		
http://www.lib.utexas.edu/maps/middle_east_and_asia/middle_east_rainfall_1973.jpg	http://www.lib.utexas.edu/maps/middle_east_and_asia/middle_east_pol_2003.jpg	http://www.cia.gov/cia/publications/factbook/geos/ir.html

Figure 2: Theme, Subject-Metter

B.3 Hard copy atlas's **Geographical Objectives and Purposes** are meant to serve knowledge and study of global areas, presented in small scale, and its designated audience is the students and the public.
Web atlas's Objectives and Purposes are meant to serve and supply objective and detailed data, obtainable in local areas, presented in a large range of scales. The designated audience, a side from the students and the public, are the planners, experts and specialists.
While hardcopy atlas consists of average information, (like geological zones, earthquakes), the web atlas provides precise maps, textual information and accurate databases. For example, a general map of earthquakes in the last 20 years is

[6] http://neic.usgs.gov/neis/current/m_east.html
[7] http://neic.usgs.gov/neis/general/seismicity/m_east.html
[8] http://www.lib.utexas.edu/maps/middle_east_and_asia/middle_east_ref04.jpg; http://www.cia.gov/cia/publications/factbook/reference_maps/middle_east.html
[9] http://www.census.gov/cgi-bin/ipc/idbpyrs.pl?cty=IR&out=s&ymax=250

presented in the hardcopy atlas, showing their static locations (see figure 3: a)[10]. In the web atlas, earthquake activity is presented not only through its nominal locations, but through its ordinal/quality distribution (like time - in the last 8 to 30 days, 2005); interval/quantitative dispersion (like depth in the last 20 years or in km); and/or volume, strength, intensity (like in magnitude) (figure 3: b,c; figure 4: all)[11].

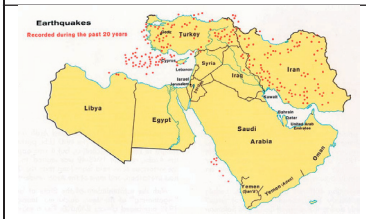
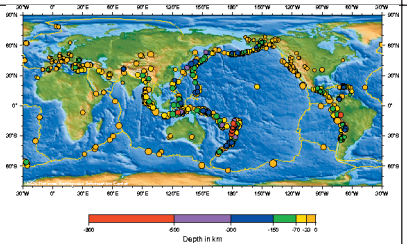
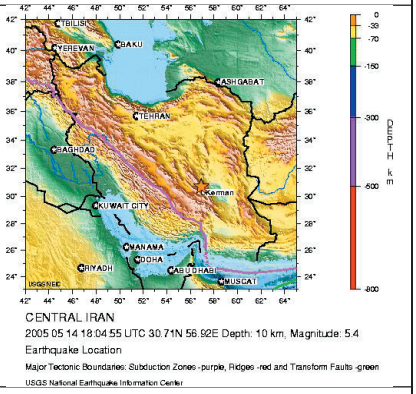
<table>
<tr><td>a. Earthquake, recorded in the last 20 years
knowledge and study of global areas, presented in small scale, and designated audience is the students and the public</td><td colspan="2">Objective and detailed data obtainable in local areas, presented in a large rang of scales. The designated audience, beside the students and the public, are planners, experts and specialists.
infinite scale in clickable map</td></tr>
<tr><td></td><td>b. Earthquake Activity in the Last 8 to 30 Days, depth</td><td>c. Magnitude 5.4, location CENTRAL IRAN, date Saturday, May 14, 2005 at 18:04:55 UTC</td></tr>
<tr><td> 
</td><td> 
</td><td> 
</td></tr>
<tr><td>http://www.lib.utexas.edu/maps/middle_east_and_asia/middle_east_earthquake_1973.jpg</td><td>http://neic.usgs.gov/neis/qed/</td><td>http://neic.usgs.gov/neis/bulletin/neic_ybbv_l.html</td></tr>
</table>

Figure 3: Geographical Objectives & Purposes

Furthermore, the combination of these event locations (points), creates elongated, narrow and uniform pattern of distribution (lines), which lead to form a pattern of earthquakes dispersion (areas), and provides indirect information about dissemination and density of hazard zones (volumes). These maps not only serve the general knowledge showing locations and sites of the geo-phenomena, but they are also linked to professional sites in which extra data, designed in large scale, offers an elaborated distribution and spatial organization of earthquakes and their interaction with other human entities (figure 4: all)[12].

B.4 The **Source of Information** of the hard copy atlas is based on a collection of measured and accurate data, which were obtained through field observation, survey and aerial photos' interpretation. The map is the storage and the documentation device, and it constitutes an agent of visual communication transfer, with certain ability to measure.
The Source of Information of the web atlas is almost the same as in the hard copy atlas. It is based on a collection of measured and accurate data: direct, indirect/ derived and statistical data base. These data are obtained through processing of verbal descriptions[13], geo-statistical sources, sharing data among professional sites linked together, and numerical data surveyed through satellites' images' interpretation. The map consists of visual communication, with the ability to interpret information through basic assumption and theoretical frameworks. The main difference between the two atlases lay in the ability of the map's editor and/or reader to create a map based on a given concept or creative opinion, depending on their view and interpretation, spatial message or say. The map is no longer the storage and documentation device only, it reflects the interpretation acquired from current knowledge and updated databases.

[10] http://www.lib.utexas.edu/maps/middle_east_and_asia/middle_east_earthquake_1973.jpg
[11] http://neic.usgs.gov/neis/qed/ ; http://neic.usgs.gov/neis/current/m_east.html ; http://neic.usgs.gov/neis/bulletin/neic_yibi_h.html
[12] http://neic.usgs.gov/neis/bulletin/neic_yibi_h.html
[13] DID YOU FEEL IT? REPORT IT HERE! http://pasadena.wr.usgs.gov/shake/ous/html/unknown_form.html

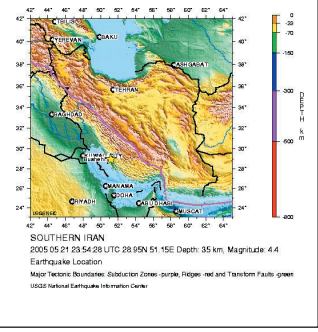
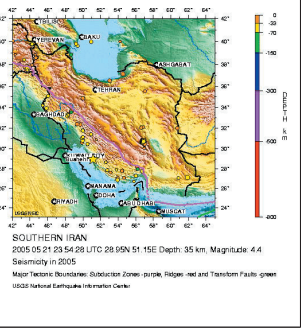
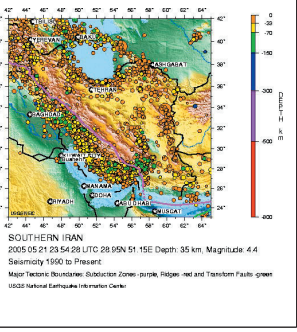
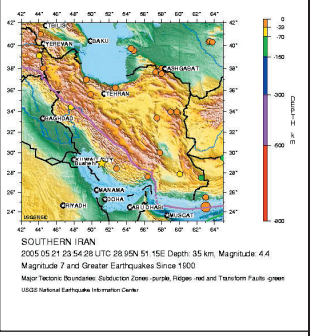
a. **Location**-Current Seismicity for the Middle East Magnitude 4.4 SOUTHERN IRAN, Saturday, May 21, 2005 at 23:54:28 UTC	b. **Distribution** over a line and time -Seismicity in 2005.	c. **Dispersion** - Seismicity since 1900 historical map	d. **Intensity** - 7 Magnitude and grater earthquakes since 1900
			
http://neic.usgs.gov/neis/bulletin/neic_yibi_h.html			

Figure 4: Geographical Objectives & Purposes, spatial organization of earthquakes in the Middle East

B.5 The component ***Interpretation and Comment*** is similar in both atlases. The interpretation of aerial/satellites images is used for identification of objects, formation, and configuration, in both the physical and the human landscapes (measuring, interpreting, assessing, inferring etc.).

B.6 A large difference between the atlases exists in ***Scaling of Geographical Phenomena*** and their ***Symbolization***

6.1 The main idea in the hard copy atlas's ***Scaling*** was to present a realistic 'copy' of landscape and configuration, in a small, fixed and finite scale of these natural entities (figure 1, a). The realistic 'photo' of landscape, is replaced in the web atlas, with a image/simulation of the human interactivities landscape and configuration, in large, flexible and changeable scale, using clickable, updated, interactive and real-time maps (figure 1, maps c,d). The physical world is no longer the main subject, but one of many possible spatial/thematic perception models of space. Thus, the intention is to express, in a graphic illustration, the geo-spatial organization between environmental phenomena and human behavior (figure 5, all).

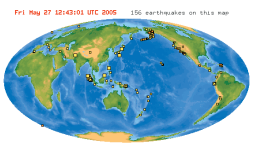
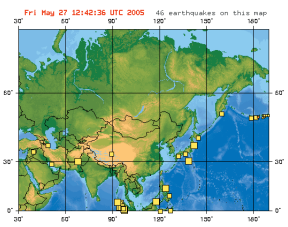
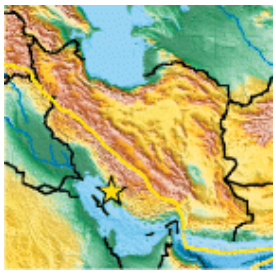
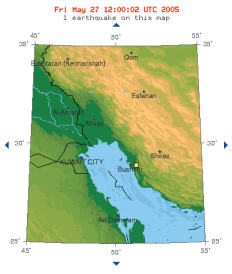
a. World Map - Clickable to Regions, recent earthquakes	**b. Asia Region**	**c. Iran, Preliminary Earthquake Report**	**d. 10 degrees map of recent earthquakes**
			
http://earthquake.usgs.gov/recenteqsww/index.html	http://earthquake.usgs.gov/recenteqsww/Maps/region/Asia.html	http://earthquake.usgs.gov/recenteqsww/Quakes/usyibi.htm	http://earthquake.usgs.gov/recenteqsww/Maps/10/50_30.html

Figure 5: Scaling of geographical Phenomena and their Symbolization of relief by: color scale, contours, shaded 3d area

6.2 The main difference between the 2 atlases is laid in the **Symbolization of Geo-data**. The web atlas major power is he fact that its database is accessible to the map reader and to his preference among the different types of mappings and

symbolization. Data Processing is based on both: conception and its symbolization. It can combine between the 'Spatial Organization' theory14 and the cartographical theory of visualization15 . The database, according to both theories, is based on datum-points of each geo-phenomenon. Their analysis can be described and displayed in a matrix/as a cross classification of 3 over 4 components. Each geo-topic can be analyzed either in their dimensions or/and their scaling categories and symbolized correspondingly.

1) Geo-phenomena and their dimensions				
	point (non d)	**line (1 d)**	**area (2 d)**	**volume (3 d)**
(2) Scaling categories	**(3) Symbols fitting each cell.**			
Nominal	Earthquake Seismicity	Fault	Oil and gas fields/ areas	hazard
Ordinal	Large earthquake	Minor/major fault	Small/big	Low/high
Interval	Depth, magnitude	Length of fault	frequency	acceleration

Figure 2: Robinson's matrix of symbolization

6.2/1 Geo-phenomena can be described in 4 ***dimensions***: An earthquake can be placed in its location (point); its distribution along a fault (line), its setting within oil and gas fields (area); its position in hazard territory (volume) (Appendix, figure 6, line 1)[16].

6.2/2 Geo-phenomena can be described in 3 ***scaling categories***: An earthquake can be placed and named by its nominal/ qualitative scaling location without any ranking (like earthquake in Bam) (figure 6, line 1); it can be expressed in ordinal scaling, classified and ranked location (major/ minor earthquake of 2005) (figure 6, line 2); it can be analyzed in interval scaling by adding quantitative information of intensity (like depth, magnitude) (figure 6, line 3).

B.7 In the hard copy atlas the ***Thematic Choice*** in Maps is selected and decided by the atlas' editor, it is fixed and it can not be changed by the map reader. In the web atlas, some databases are accessible, open and can be efficiently used by the reader/teacher/student. In such a way, a Thematic Choice in Maps can be offered by the editor, decided and executed not only by the map producer specialist, but even by a low-qualified person.

7.1 In all ***geo physical relief*** and its ***3d presentation***, the data is a compilation of datum points (X,Y,Z), stored in digital and web databases and interpolated in stations. The data components and their dispersal were linear, sequential series, presented with 3d isometric mapping (like elevation -contours, isotherms, isobars, geology structure, or earthquake history). This type of storage simplifies the thematic choice of 3d presentation.
The hardcopy atlas's thematic choice of 3d relief is performed on color scale of elevation, contours, shaded 3d area, or some combination of them. Mapping the land form was based on layer coloring according to altitude, relief map with 3d contours model (isometric mapping with isarithm, hachuring, analytical shading etc). While the physical world was the main idea, the human overlap was secondary and little attention was made to represent it.
The common 3d relief presentation in the web atlas remains the same, but it goes furthermore to websites in which describing and mapping the surface is based on the detailed and accurate datum itself.
The socio-cultural series and its distribution are neither continuous, nor consecutive, and it is presented with 3d choroplathic mapping, based on data collected in administrative units/states (areas).

7.2 Many efforts were made to improve ***the Socio-cultural landscape 3d presentation***, in the web atlas' maps, its data of human distribution, its thematic mapping and its 3d presentation. Most of the geo-socio-cultural data is collected in locations (settlements, urban/rural household units, etc).It is stored in digital web databases, formatted by the states' Central Bureau of Statistics. This storage and its generator simplified the thematic choice of 3d presentation. In both atlases the human space is mapped thematically focusing on settlements, describing their locations with point symbols, their population size with graduated symbols and their ethnic origin with segmented symbols. Most of the human data are described and represented in Choropleth mapping, based on administrative districts or states. This mapping is 'safe' for it simply symbolized the quantities where they exist, but it is the least informative and analytical methods presenting and mapping these kind of dispersals. Furthermore, the Dasymetric, Isarithmic and Isoplethic Mappings, which describe relative positioning of human processes, their trends, directions, and gradients, are rarely used (figure 7: all maps).

[14] Abler R., Adams J.S., and P. Gould, (1972): ***Spatial Organization***, Prentice-Hall int. London, 93-101; 255-271
[15] Robinson A. & Sale R., (1969): ***Elements of Cartography***, John Wiley & sons, 3rd ed. pp 93, fig. 5.1
[16] http://www.iiees.ac.ir/English/bank/Bam/bam_report_english_recc.htm

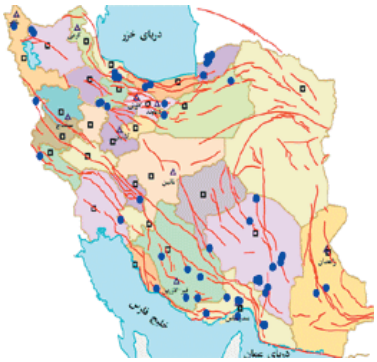
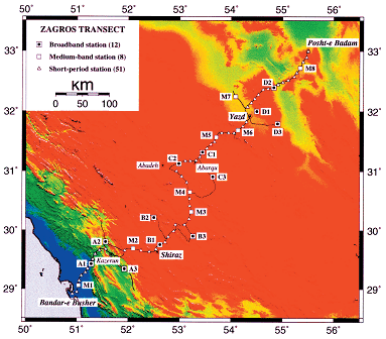
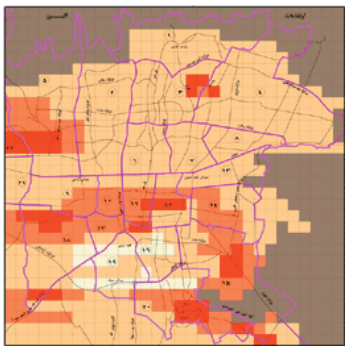
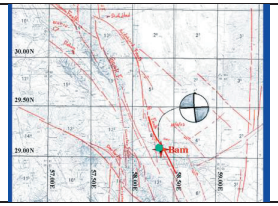
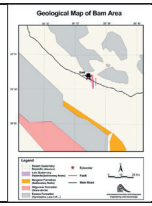
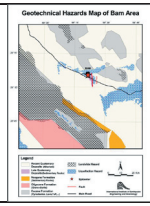
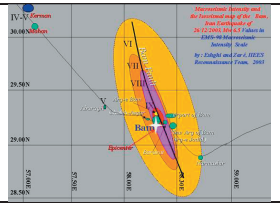
Choropleth mapping	**Isarithmic mapping**	**Isoplethic Mappings**
National Center for Earthquake Prediction	Broadband National Seismic Network	Experimental Soil Mechanics and Engineering Physical Modeling Department
		
http://www.iiees.ac.ir/English/Prediction/eng_predict.html	http://www.iiees.ac.ir/English/Seismology/eng_seis.html	http://www.iiees.ac.ir/English/Geo/eng_geo_groups.html#Experimental%20Soil%20Mechanics%20and%20Engineering%20Physical%20Modelling%20Department

Figure 7: Thematic Choice

CONCLUSION

B.8, 9 In both atlases, the map is a magnificent device for spatial data collection, storage, documentation, conservation, and information delivery. But the main difference lies in accessibility, processing and updating of geo-data, leading to updated map products. The hard copy atlas is physical and regional, static, having a fixed and definite scale, using Isarithmic mapping. The web atlas is socio-cultural and spatial, dynamic and accessible, flexible in scale, untied to any mapping, and encouraging processing, symbols and thematic choice. Even though the web atlas and its accessibility to databases are expected to be used as a ***research tool*** for spatial analysis, integration and synthesis, it is hardly found and remains a utopia. Although a map is expected to be a ***logical framework within which theories are built***, it is absurd, it can rarely be found as a ***research tool***. Is it are too much to ask for??

Scaling of Geographical Phenomena and their Symbolization		Symbolization of geo-data according into 4 categories of dimensions: point (non dimensional), line (one dimensional), area (2-dimensional), and volume (3- dimensional		
				Categories of dimensions Geographical objectives
point	**line**	**area**	**volume (3 d)**	**volume + time(3 d)**
Location and site map of the epicenter and the reactivated Bam fault. The surface fissures created after Bam earthquake of 26/12/2003 are shown with dashed lines.	**Distribution** The fault map of the Bam earthquake prone area of the 26/12/2003 earthquake	**Dispersion** The simplified geologic map of the area	**Dispersion** Geotechnical hazard map of Bam area	**Density** The Macro seismic intensity and the isoseismic Intensity map of the area (Eshghi and Zare, 2003)
				1. nominal
 				
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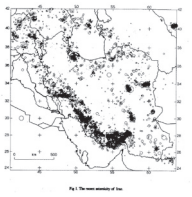
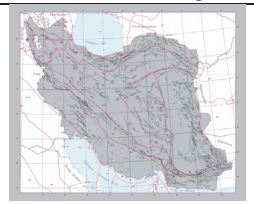
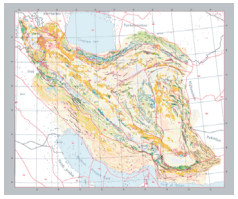
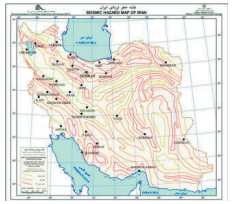
				2. Ordinal
Location of recent seismicity of Iran	**Distribution** of falts, oil and gas fields	**Dispersion** of geology, oil and gas fields and geologic provinces of Iran	Seismic Hazard Map of Iran	
				
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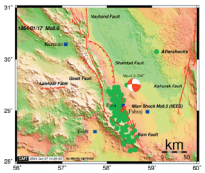
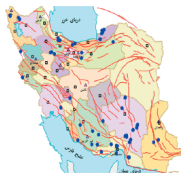
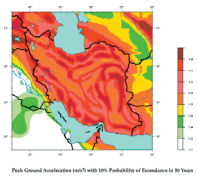
				3. Interval
Depth, magnitude The information of Bam earthquake and its aftershocks, 26/12/2003 Bam earthquake		National Center for Earthquake Prediction	Peak Ground Acceleration (m/s²); GLOBAL SEISMIC HAZARD ASSESSMENT PROGRAM	
				
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Figure 6: Robinson matrix of symbolizat