Calculation of the change of percentage in Malaysia's population using GIS and its implications for Science and Technology Education

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ABSTRACT

Geographic Information Systems (GIS) is one of many information technologies that has transformed the ways geographers conduct research and contribute to society. In the past two decades, this technological tool has had tremendous effects on research techniques specific to the discipline, as well as on the general ways in which geographers communicate and collaborate. In the context of these innovations, GIS has emerged as a very powerful integrating technology because it allows geographers to integrate their data and methods in ways that support traditional forms of geographical analysis, such as map overlay analysis as well as new types of analysis and modeling that are beyond the capability of manual methods. The development of GIS has relied on innovations made in many different disciplines: Geography, Cartography, Photogrammetry, Remote Sensing, Surveying, Geodesy, Civil Engineering, Statistics, Computer Science, Operations Research, Artificial Intelligence, Demography, as well as many other branches of the social sciences, natural sciences, and engineering which have all contributed, queried, and analyzed large quantities of data all held together within a single database. This paper aims at exploring the various technical features of GIS via tracing its historical revolution and the applications of geographic information in daily life such as the mapping of population data. Discussions will also be made to illuminate the aspects of GIS in education and training focusing on the integration of cross-curricular and interdisciplinary approaches in school curriculum, such as Science, Mathematics, Technology, Geography and Language. Case example will be illustrated on a topic "Dwelling" as suggested by "Science Across the World" (SAW) web-based international programme for secondary students taking the subjects of Science or Social sciences. Students could be guided to explore the use of GIS tool in mapping the population in various states of a country, e.g. Malaysia with the population data downloaded from the Internet via literature search on the statistical survey of Malaysian population. The calculation of the percentage of change in population will also be illustrated through the various graphical formats of GIS. Using SAW database, students could be encouraged to exchange information with other students on the output of their survey and their understanding on the various aspects of population density that may affect the lifestyle of the citizen such as rules and regulations governing the construction of building in community, water supply, sewage system, health, communication, etc. Discussions will also be made on the future directions of GIS in education and training.

Key Words: Surveying, Tracing, Mapping, Artificial Intelligence, Global and regional geographic information sharing, GIS education and training

INTRODUCTION

The advent of cheap and powerful computers over the last few decades has paved the way for the development of innovative software applications for the storage, analysis, and display of geographical data. Many of these applications belong to a group of software known as Geographical Information Systems (GIS). GIS is one of many information technologies that has transformed the ways geographers conduct research and contribute to society. In the past two decades, this technological tool has had tremendous effects on research techniques specific to the discipline, as well as on the general ways in which geographers communicate and collaborate. In the context of these innovations, GIS has served an important role as an integrating technology. Rather than being completely new, it has evolved by linking a number of discrete technologies into a whole that is greater than the sum of its parts. GIS has emerged as a very powerful technology by allowing geographers to integrate their data and methods in ways that support traditional forms of geographical analysis, such as map overlay analysis as well as new types of analysis and modeling that are beyond the capability of manual methods.

The importance of GIS as an integrating technology is also evident in its pedigree. The development of GIS has relied on innovations made in many different disciplines: Geography, Cartography, Photogrammetry, Remote Sensing, Surveying, Geodesy, Civil Engineering, Statistics, Computer Science, Operations Research, Artificial Intelligence, Demography, as well as many other branches of the social sciences, natural sciences, and engineering which have all contributed, queried, and analyzed large quantities of data all held together within a single database. This paper aims at exploring the various technical features of GIS via tracing its historical revolution and the applications of geographic information in daily life such as the mapping of population data. Discussions will also be made to illuminate the aspects of GIS in education and training focusing on the integration of cross-curricular and interdisciplinary approaches in school curriculum, such as Science, Mathematics, Technology, Geography and Language. Case example will be illustrated on a topic “Dwelling” as suggested by “Science Across the World” (SAW) international programme for secondary students taking the subjects of Science or Social sciences.

BACKGROUND OF STUDY AND LITERATURE REVIEW

SAW is a web-based international programme founded by the Association for Science Education (ASE) of the United Kingdom (UK) (Website: http://www.scienceacross.org) supported by GlaxoSmithKline (GSK). Through its partnerships with SAW teachers, students, and other stakeholders, the programme aims to stimulate interest and confidence in science among young people, as well as to promote awareness and discussion of scientific issues that affect people’s lives around the world. Students can communicate world wide about a range of globally important issues (SAW, 2000). There are times when several content subjects or parts of subjects are integrated with science, or other subjects are introduced via cross-curricular approach, i.e. the teaching of science across other subject disciplines. Other distinct features in SAW programme are that science subjects could also be taught interdisciplinary. A *cross-disciplinary or interdisciplinary approach* refers to cases where professional scientists, working mainly in one major discipline, often have to apply or refer to science ideas located within a different science discipline. For example, a geologist’s study of soil (Earth science) may involve studying chemicals within soil (chemistry) and living organisms in soil (biology), along with gravity’s effect on water moving through soil (physics) (Gega, 1994). Interdisciplinary approach could also be applied incorporating the teaching of various science disciplines (Biology, Physics, Chemistry) with other interrelated disciplines, e.g. maths, technology, environment, as illustrated in the following statements by the SAW stakeholders (Ng and Fong, 2004) :

"*Science Across the World is a tremendous example of making science come alive for kids. The new road safety curriculum demonstrates uses of maths, science and technology in the real transportation world.*" (Secretary, U.S. Department of Transportation).

(SAW, 2000).

"…Not only did the project provide a global awareness of issues e.g. water, it promoted a link to various communities (hydro, gas, utilities, water companies). Students were motivated to learn…" (Teacher from Trinity College School, Port Hope, Ontario, Canada)

(SAA, 1997).

In this study, the authors will explore the possibility of teaching the SAW topic "Dwelling" to secondary students via cross-curricular and interdisciplinary approaches using ICT (incorporating web-based learning and GIS) and other curricular disciplines, i.e. Science, Mathematics, Environmental Science, Health and Social Science subjects such as Geography, Culture and English Language in Science Learning.

Definition and brief history of GIS

Many definitions have been proposed for what constitutes a GIS. Each of these definitions conforms to the particular task that is being performed. Instead of repeating each of these definitions, the authors would like to broadly define GIS according to what it does. The activities which are normally carried out on a GIS include :

- The measurement of natural and human made phenomena and processes from a spatial perspective. These measurements emphasize three types of properties commonly associated with these types of systems: elements, attributes, and relationships.

- The storage of measurements in digital form in a computer database. These measurements are often linked to features on a digital map. The features can be of three types: points, lines, or areas (polygons).

- The analysis of collected measurements to produce more data and to discover new relationships by numerically manipulating and modeling different pieces of data.

- The depiction of the measured or analyzed data in some type of display - maps, graphs, lists, or summary statistics.

In the 1980s and 1990s, many GIS applications underwent substantial evolution in terms of features and analysis power. Many of these packages were being refined by private companies who could see the future commercial potential of this software. Some of the popular commercial applications launched during this period include : ArcInfo, ArcView, MapInfo, SPANS GIS, PAMAP GIS, INTERGRAPH and SMALLWORLD. It was also during this period that many GIS applications moved from expensive minicomputer workstations to personal computer hardware.

GIS is the merging technology that can enable positive change to the way we do business. It has the power to improve services, increase production, improve information management and enrich financial results. This is affected through re-engineering business processes of companies, industries and governments who strive to integrate spatial information and the data to which it interfaces.

GIS software nowadays are capable of performing basic to advanced analysis, varying from measuring distances, perimeters, and areas to dealing with proximity, connectivity, and containment as well as networking, buffering (flood zones, address notification), line of site (slope), and spatial analysis. Thus, GIS is capable of numerous tasks including (but not limited) to the following:

- Input and update spatial and attribute (e.g., plot owner) data.
- Combine data from different sources.
- Link spatial data with attribute data.
- Analyze multiple data sets.
- Convert coordinate system.
- Convert data formats.
- Export to other data formats.
- Generate analog maps and tabular reports.

RESEARCH METHODOLOGY AND THE INTEGRATION OF GIS IN SCIENCE EDUCATION VIA CROSS-CURRICULAR AND INTERDISCIPLINARY APPROACHES

Rationale for the Integration of GIS in Science and Technology Education

As discussed earlier, literature reviewed supports the following main functions of GIS in general:

- Maintain and retrieve large quantities of data
- Manipulate spatial and related tabular data
- Perform complex spatial analysis
- Rescale data for analysis
- Create thematic maps

It has also been widely used in many disciplines, including the more specific aspect of science and technology education as well as social sciences. GIS can help learners of all ages understand the world around them. It helps students and teachers engage in studies that promote critical thinking, integrated learning, and multiple intelligences, at any grade level.

In classrooms across the country and around the world, educators are using GIS in the study of topics as varied as Environmental Studies, Geography, History, and Economics. GIS also provide powerful tools for addressing geographical and environmental issues including the survey of population and its effects on culture, health and lifestyle.

Methodology for data collection and implementation of GIS

The data collection method for this study will be mainly through web-based literature research to trace the historical revolution of GIS and the integration of web-based cross-curricular science and technology education. Various technical aspects of GIS will be explored, including the applications of geographic information in daily life such as the mapping of population survey data to be manipulated on GIS and being interpreted scientifically by educators and learners. The following will outline the technical aspects of GIS (which was downloaded as freeware from the Internet via the website : http://www.library.uu.nl/wesp/populstat/Asia/malaysip.htm)

with illustrative guides given for the implementation of GIS in science and technology education.

The technical features of GIS : ArcView's Project / Document Data Structure:

(1) The Project File *(utm.apr) :*

A Project file can be thought of as being a folder that stores ArcView Documents. Actually, **Projects do not contain duplicates of spatial or tabular data, but merely store "pointers" to the original data**, as well as storing the display formatting of Views, Tables, Charts, Layouts and Themes.

Project Documents include the following features :

View - A "View" is a collection of geographic features, grouped by Themes. A View has two components: a Table of Contents and a display window.

Tables - A "Table" is a collection of attribute data, typically linked to spatial features in a Theme.

Charts - A "Chart" is a graphic representation of attribute data in a Table. A Chart can be dynamically linked to both a Theme and a Table.

Layouts - A "Layout" is a collection of other ArcView Documents in map format.

(2) Scripts :

A "Script" is a computer program written in Avenue that allows the user to add new capabilities to ArcView, automate tasks, and build customized applications.

All document types may be accessed from the Project Window by clicking the appropriate document icon and double clicking on the document of interest in the list.

(3) Theme :

A "Theme" can be defined as a single layer of spatial information in a View.

(4) The Extension Manager :

The "Extension Manager" allows the user to incorporate "add-on" modules to the basic ArcView package. ESRI and third party vendors develop these "add-on" modules which are termed as "Extensions". Extensions are collections of Avenue scripts, ArcView programing language, that allow the user to perform specialized GIS functions, for examples : ESRI's Spatial Analyst and Network Analyst. To "turn-on" these extensions in **ArcView**, choose **File** and release on **Extensions ...** from any document Menu Bar (discussed later). Click the check box to turn-on the extension. If the user click once on an extension name, ArcView will display information about the Extension.

(5) Arc View Introduction :

"ArcView" is a useful software or desktop GIS and mapping. It is a product of Environmental Systems Research Institute, Inc. (ESRI). ArcView GIS is a powerful software that provides for visualizing, querying, exploring, and analyzing data geographically. ArcView is a powerful GIS tool that can display information (which resides locally or over a distributed network), read spatial and tabular information from a variety of data formats, access external databases, produce thematic maps (use colors and symbols to represent features based on their attributes), perform spatial queries, connect spatial information to database attributes, provide several analytical tools, and allows for a high degree of customization using Avenue.

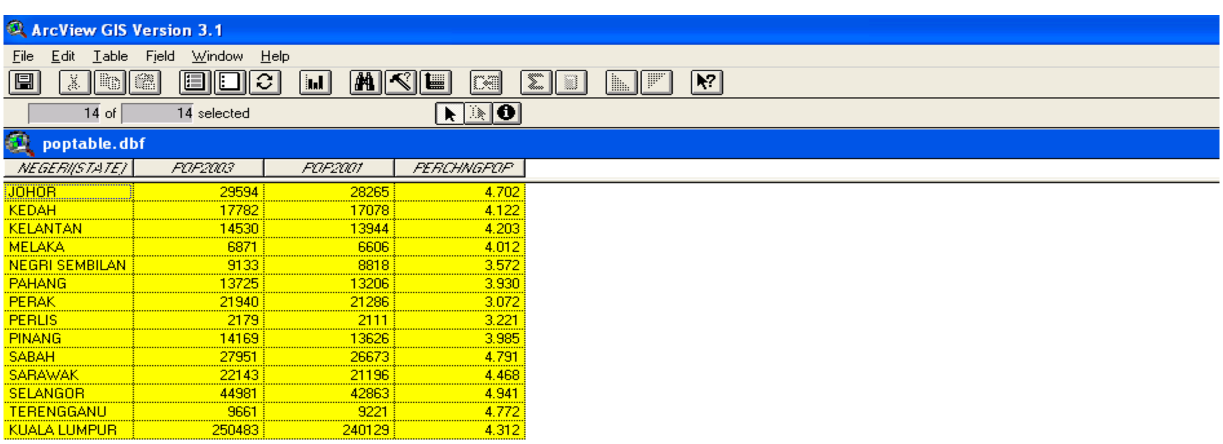
(6) Tables :

"Tables" are ArcView's representation of data. They contain descriptive information about specific subjects. Each row (or record) defines one entry in the database (e.g., one county polygon) while each column (or field) defines a single characteristic for the entry. Any database file (dbf, INFO, or ASCII) can be displayed as an ArcView Table. Regardless of the source of table, all tables appear the same to the user in ArcView. ArcView defines a standard template to reference the table in which the user accesses. The tabular data itself is not imported, but rather continues to be stored in the source file in its native format. The ArcView link to the data is dynamic (i.e., changes in the data outside ArcView will be reflected in ArcView projects with reference to these data).

In the following section, the authors will illustrate the use of GIS in the demographical study. ***Figure 1*** displays the "Print screen" picture of the mapping of population data in various states of Malaysia in the years 2001 and 2003 with the percentage of population growth. The procedures for the calculation of the percentage of increase of population can be viewed from ***Figures 2*** and ***3*** respectively. The user could simply click on the icons "Field", "Calculate" and enter the following formula in the column as shown in ***Figure 3***.

(pop2003 - pop2001) / (pop2001) * 100

Figure 1 : ArcView's representation of data captured via computer "Print screen"



NEGERI(STATE)	POP2003	POP2001	PERCHNGPOP
JOHOR	29594	28265	4.702
KEDAH	17782	17078	4.122
KELANTAN	14530	13944	4.203
MELAKA	6871	6606	4.012
NEGRI SEMBILAN	9133	8818	3.572
PAHANG	13725	13206	3.930
PERAK	21940	21286	3.072
PERLIS	2179	2111	3.221
PINANG	14169	13626	3.985
SABAH	27951	26673	4.791
SARAWAK	22143	21196	4.468
SELANGOR	44981	42863	4.941
TERENGGANU	9661	9221	4.772
KUALA LUMPUR	250483	240129	4.312

Figure 2 : Calculation of percentage of population increase captured via "Print screen"

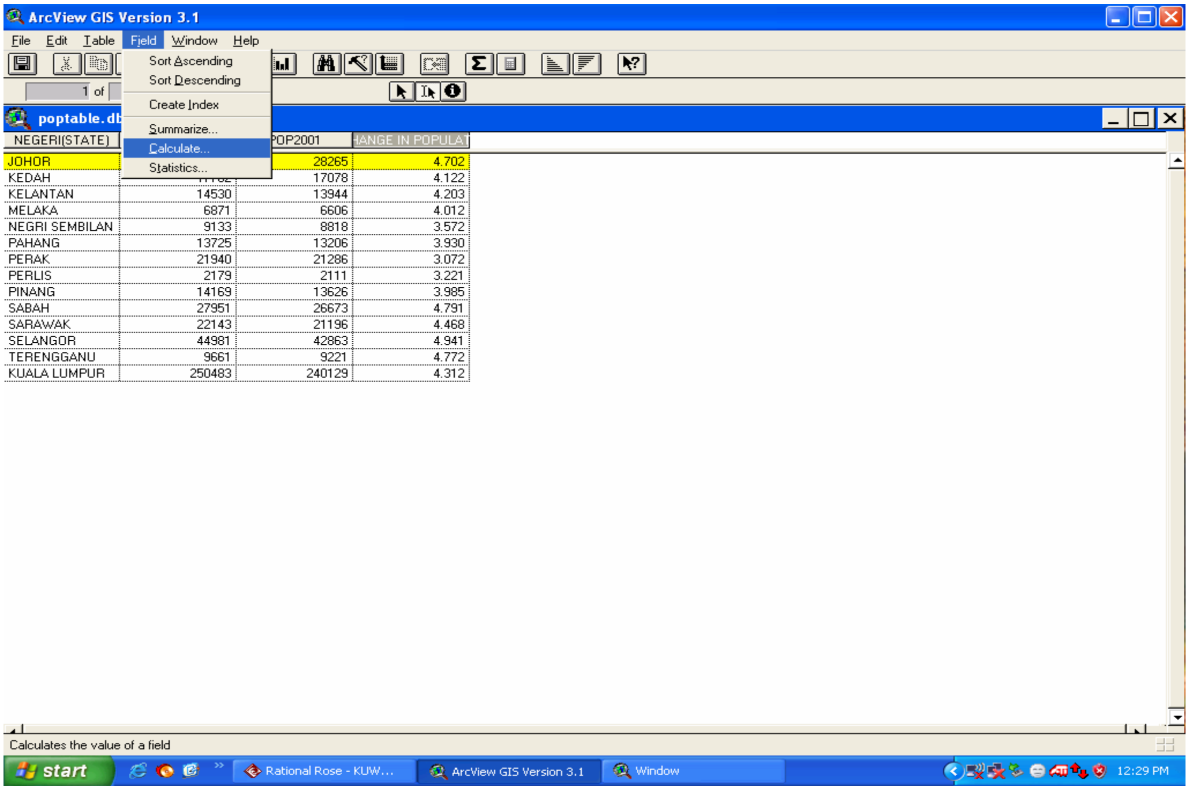
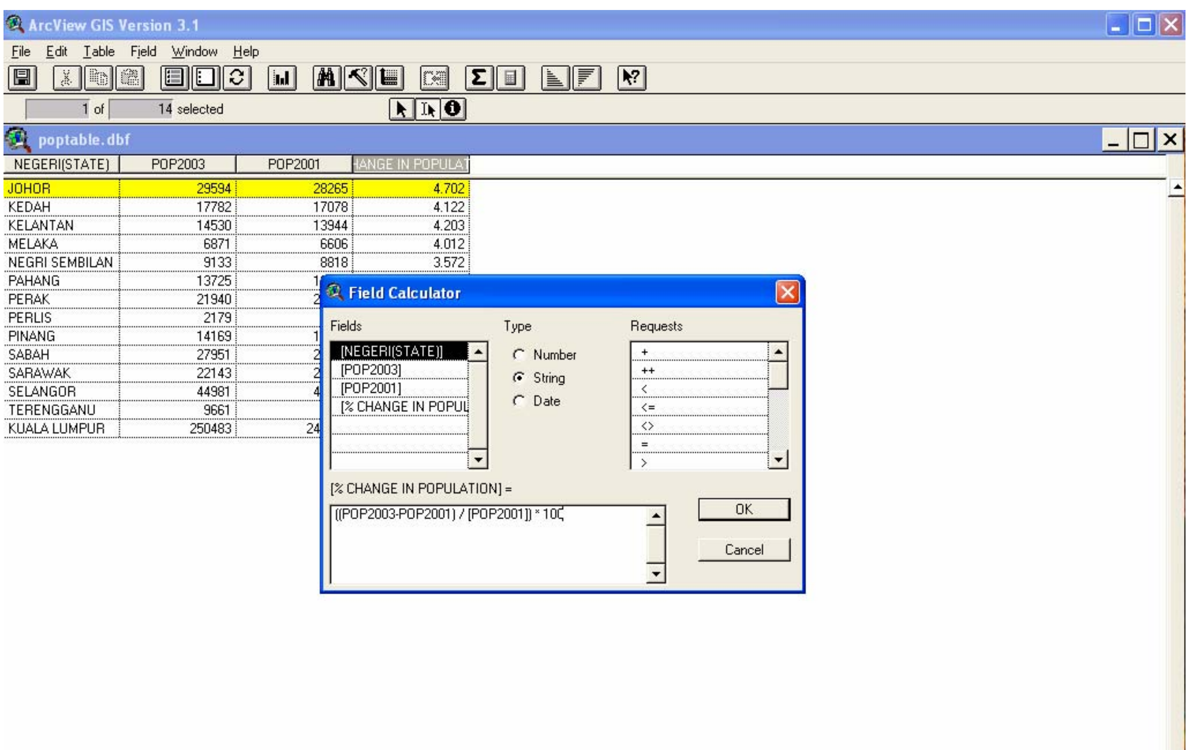


Figure 3 : Entering the formula for the calculation of population increase



(7) Charts :

Charts in ArcView GIS are very useful tools to display, compare, and query data. Charts provide graphic representation of summarized tabular data (especially attributes of geographic features) that can quickly convey information. Charts can also query geographical and tabular data. Charts in ArcView are especially powerful since they are linked to the themes in a view. A chart is dynamic so it reflects the current status of the data in the table. If the user edit the table in ArcView, the chart will immediately reflect the edit. If the tabular data source is edited, the change will be reflected in the table and the chart when the user choose "Refresh" button from the "Table" menu or the next time the user open the project.

Different charts representing the data (e.g.) can also be created for different purposes. Six different chart types are available in ArcView, i.e. line, bar, column, xy scatter, area, and pie. Each contains a variety of chart styles for the user to choose from. For example, ***Figure 4*** displays the graphical view of the percentage (%) change in the population in various states between 2001 and 2003 in the form of column chart.

Figure 4 : Graphical view in the form of column chart for the % change in population

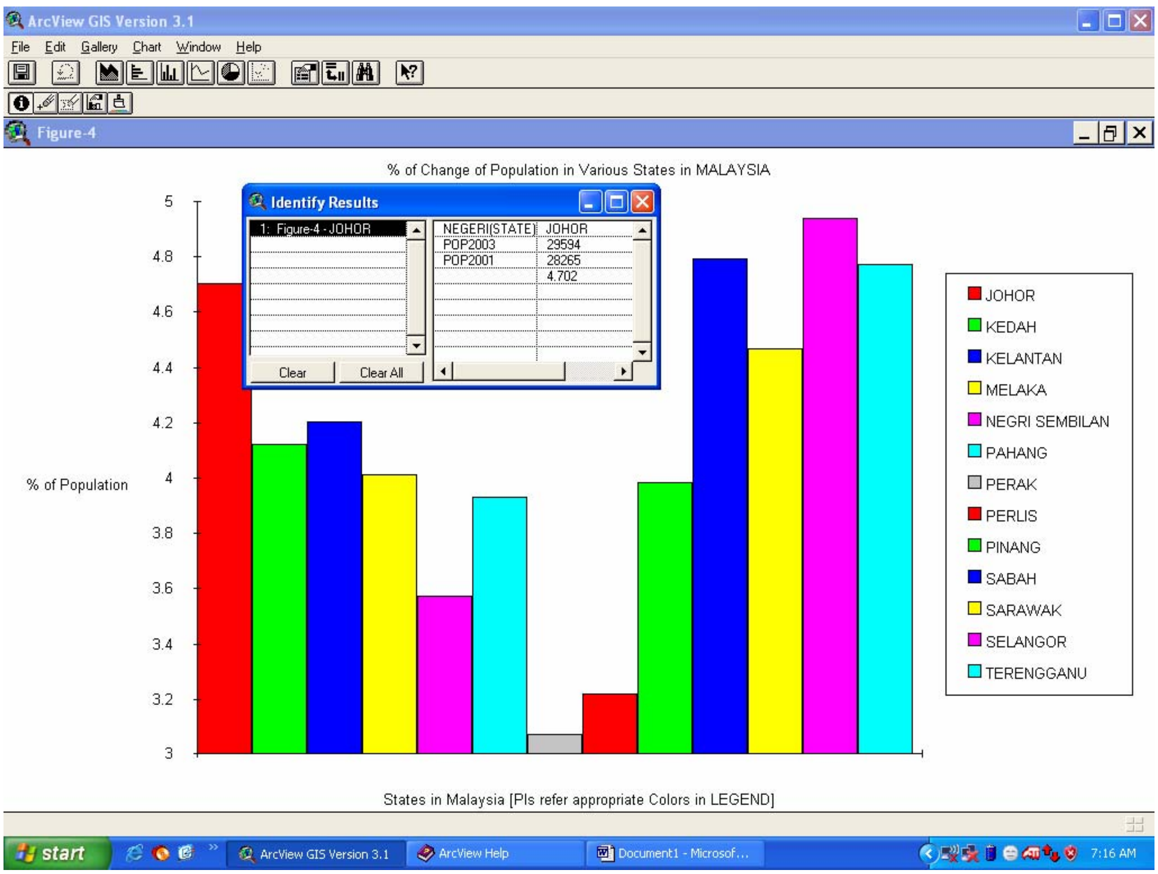


Figure 5 : Graphical view in the form of bar chart for the % change in state population

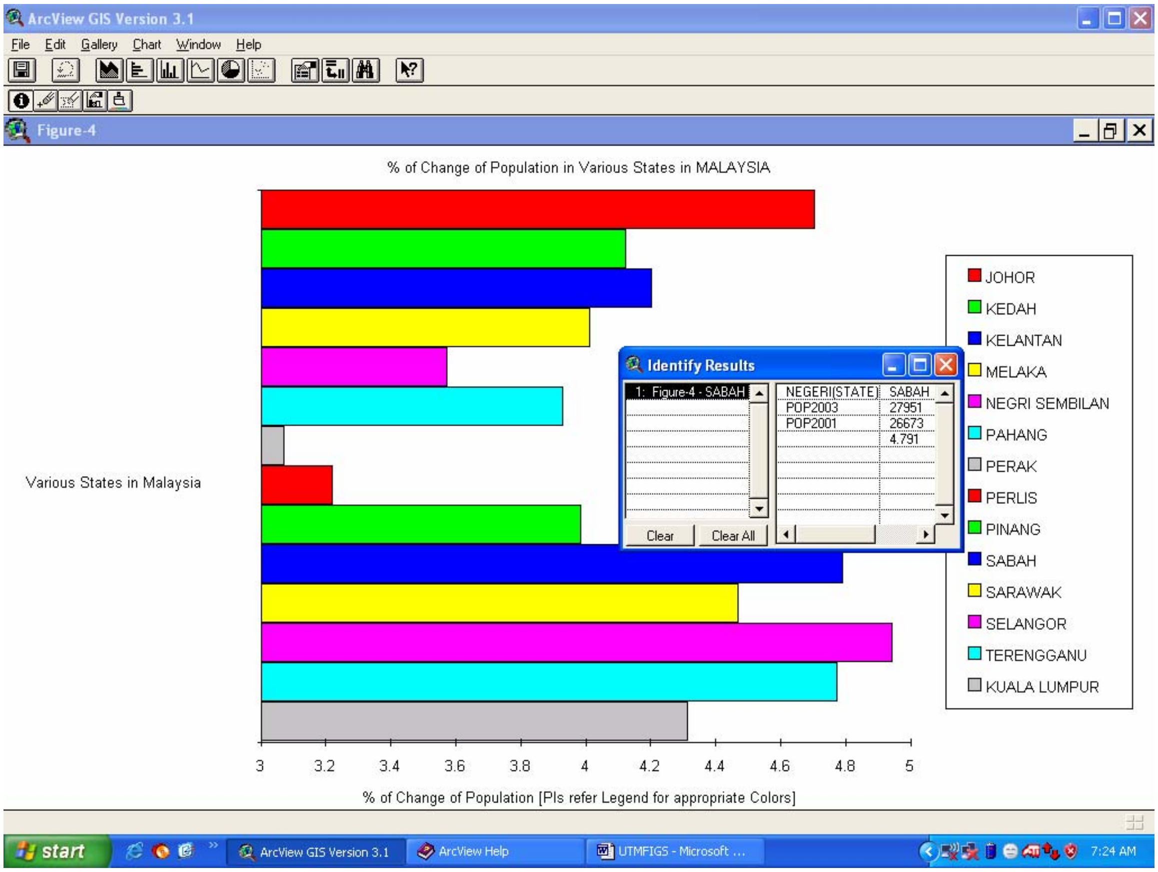
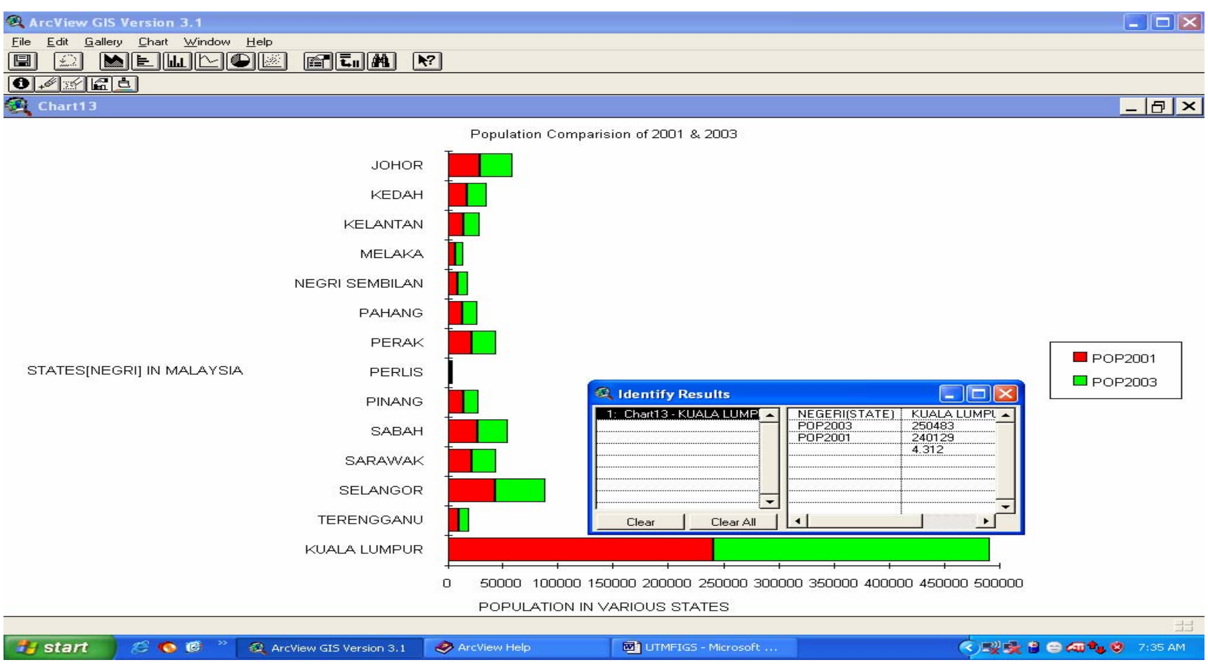


Figure 6 : Graphical view of statewise population



The same data could also be presented in the form of bar chart as illustrated in ***Figure 5***. In this case, the user can clearly interpret from the data that among all the states in Malaysia, Selangor is the state with the highest percentage of increase in population between 2001 and 2003 with 4.9%

Whereas ***Figure 6*** displays another format of the growth of population. In this case Kuala Lumpur is shown to be the state with the highest growth of population at the rate of 4.312% (reflected in the table “Identify Results”).

The integration of GIS in science and technology education via cross-curricular and interdisciplinary approaches

This section will discuss the aspects of GIS in education and training focusing on the integration of cross-curricular and interdisciplinary approaches in school curriculum, such as Science, Mathematics, Technology, Geography and English Language in Science/Maths teaching. An example is given on the teaching of SAW topic “Dwelling”. Secondary school students are suggested to register an account for the school, add this topic in their school database and invite schools that have registered for this topic to do exchange with them. They could download the exchange form from the Internet by clicking the icons of “Dwelling” and download “Exchange form in word format". Then they can carry out individual or group survey in their respective local communities to respond to the questions listed in the form, such as "Rules and regulations governing the construction of houses in communities" (*Refer blank exchange form attached*).

Students could also be guided to do extension enrichment activities incorporating use of ICT in science learning to explore various issues or factors affecting “Dwelling”. In this case they could be guided to explore the use of GIS tool in mapping the population in various states of Malaysia and finding the percentage of change in population as discussed above. From the interpretation of the data (such as those outlined in ***Figures 1*** to ***6***) and graphical map drawn on the demographic distribution of population, students could discuss the implications for their survey. For example, how will the information obtained from this study help to inform town planners or citizens living in the society about issues related to water supply or sewage system, air or land pollution that affect health, communication, lifestyle and other related concerns such as rules and regulations governing the construction of building or the design and shape of houses in the community. Using SAW database, students could exchange with students from other parts of the world using the information they have consolidated from their class survey and the discussion output of their understanding on the various aspects of population density that may affect the lifestyle of the citizen in their respective community.

CONCLUSION AND FUTURE DIRECTION

The output of GIS data for this study has in fact served as a good statistical information for various fields of professionals to improve quality living. For example, construction company will be better informed of the needs to build houses and the types of constructions in the locality with different population density. Health care professionals will also be more aware of the needs to take various health prevention measures and health promotion programmes as it is believed that densely populated areas will have higher risks of contacting epidemic or endemic diseases. When citizens in a country are informed of the overpopulated area, they will consider migrating to the less populated area for various concerns related to health and lifestyles, as what has been practised in India so far.

Since GIS is one of the latest technologies, it is believed that there are a lot of areas that could be explored especially related to education, training, global and regional geographic information sharing and international collaboration. It is hoped that this article has one way or another initiated the discussions for the way forward, especially to incorporate GIS in the teaching of science and technology education via cross-curricular and interdisciplinary approaches.

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