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Development and operation of GIS exercise materials for undergraduate students

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ABSTRACT

Since around 2000, GIS researchers in Japan have collaborated to provide materials for GIS lecture classes for university undergraduates. As a result, a GIS core curriculum, a Japanese version of GIS Body of Knowledge (BoK), and a series of PowerPoint presentation files were developed. These materials are online and available to anybody with free of charge. However, they have not yet published free-access online materials for GIS exercises using software and spatial data. Therefore, we launched a new project in 2015 to produce such materials. The learning topics in the materials were selected based on products from the previous projects. Software packages used for GIS operations are free open-source ones. The materials have been provided as open educational resources with a Creative Commons license on the GitHub platform. The materials were used in a university class of GIS exercises to verify whether they are effective for undergraduate students. In this paper, we introduce the developed materials and show the results of their applications.

INTRODUCTION

Since around 2000, many projects related to GIS education have been conducted in Japan. The first draft of a Japanese GIS core curriculum was published in 2004, and the third draft was finalized in 2008. Sadahiro et al. (2012) also compiled a Japanese version of GIS Body of Knowledge (BoK) based on the Japanese core curriculum. Researchers also provided a series of Microsoft PowerPoint files for lectures to teach GIS. The developed materials have been online and available to anybody. To summarize these outcomes, a textbook in Japanese entitled "Geographic Information Science: GIS Standard" was published (Asami et al. 2015). In these previous projects, some materials for GIS exercises corresponding to part of the GIS core curriculum were also developed (e.g., Takahashi and Okabe 2008). However, these materials contain only limited learning contents and use an expensive software package for GIS operations. Also, the materials were stored in a closed system and access to them required an ID and a

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password. Therefore, in 2015, we launched a new project for developing freely available online materials for GIS exercises. The materials have already been published and accessible by anybody.

DEVELOPING MATERIALS FOR GIS EXERCISES

Education of GIS exercises used to require expensive commercial software. In recent years, however, various free and open-source GIS software packages became available. Using such software, anybody can learn GIS with free of charge. On the other hand, such software was not widely used in GIS education at Japanese universities. Therefore, we decided to utilize such free software. The materials consist of various learning items for systematic GIS education.

Among free GIS software packages, our materials mainly utilize QGIS. When items include operations difficult to conduct only with QGIS, other software packages are also used. For example, in the case of topographic analysis, GRASS GIS and SAGA GIS are employed for handling digital elevation models (DEMs) in raster.

The materials were developed with markdown files for the GitHub platform. GitHub is a web-based Git hosting service and can easily visualize markdown files. It is commonly used for developing open source software and managing software manuals by way of social coding. Using this system, anybody can join our project to suggest editing and fixing of the materials. However, the materials composed of markdown files may be troublesome in terms of usability, visibility and accessibility. To reduce this problem, we use the GitBook library that allows us to convert markdown files into an e-book style (Figure 1). The materials are recognized as open educational resources with a Creative Commons license.

Table 1 shows major sections and features of the materials. Developed materials are divided into four courses. The entry course explains basic GIS operations such as map layout and opening an attribute table. The beginner course explains methods of basic spatial analysis under some different situations. This course also introduces methods of data download from web sites and creating data within GIS. The expert course deals with more statistical spatial analysis such as spatial autocorrelation and interpolation. We also developed the extra course to learn field surveys using GIS-related equipment and applications of WebGIS. The materials concerning field equipment explain how to use survey equipment such as UAVs (unmanned aerial vehicles) and the Geopaparazzi tool for mobile GIS. The materials for learning WebGIS focus on tools to create a web map with simple programming using the Leaflet and CesiumJS libraries.

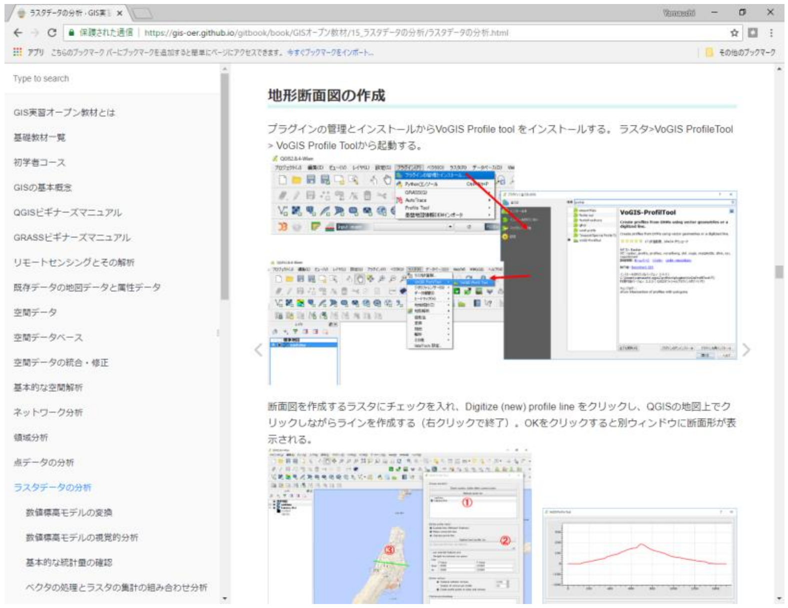

Figure 1. Interface of developed materials
（https://gis-oer.github.io/gitbook/book/）

Table 1. Major sections and features of materials

Title	Main applications	Course
Representation Strategies for mapping	QGIS	Entry
Design of the maps	GRASS GIS	
Remote sensing and analysis	MultiSpec, QGIS	Beginner
Useable map data and attribute data	WEB browser	
Spatial data conversion	QGIS	
Spatial database	PostGIS, QGIS	
Merging and correction of spatial data	QGIS	
Basic spatial analysis	QGIS	
Network analysis	GRASS GIS, QGIS	
Region analysis	QGIS	
Point data analysis	QGIS, CrimeStat	
Raster data analysis	QGIS, GRASS GIS	
Visual communication using the maps	QGIS	
PGIS and social contribution	OpenStreetMap, QGIS	
Trend surface analysis	SAM	Expert
Spatial autocorrelation	CrimeStat	
Spatial interpolation	QGIS, GRASS GIS ,SAGA GIS	
Spatial correlation	R, SAM	
Scale of spatial analysis	GeoDa	
Use of equipment for field surveys	Geopaparazzi, etc.	Extra
Creating a web maps	Leaflet, CesiumJS, etc.	

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USE OF MATERIALS IN A CLASS

The materials were used in a class for undergraduate students to verify whether they are effective in GIS education. The class was held as an intensive course of three days in January 2018 at The University of Tokyo. The class consisted of a lecture part in the morning and an exercise part in the afternoon. The exercise part took four hours each day. The students who joined the class were mostly junior undergraduates at the Department of Earth and Planetary Science. Seventeen students attended the class in all three days. In the beginning of each exercise, the teacher explained a summary of learning sections and tasks for the students. After that, the students learned GIS operations by themselves using the online materials and QGIS. The main tasks for the students were creating three to four maps each day. The exercise class for each day consisted of three to four sections (Table 2). The first day class had three sections: QGIS entry operations, downloading the GIS data, and merging and correction of spatial data. On the first day, the biggest priority was getting used to GIS software and spatial data. The second day class had four sections: spatial data conversion, basic spatial analysis such as clipping, network analysis, and region analysis. The third day class had four sections: point density analysis, topographic analysis, watershed analysis, and spatial interpolation. Through these exercises, students learned how to use different types of data according to learning topics.

At the end of each day, we conducted a questionnaire survey to understand how the students evaluate the difficulty, understanding and satisfactory levels of the exercises, as well as the usability and understandability of the materials. Each answer was a selection from five levels, such as easy, relatively easy, intermediate, relatively difficult, and difficult. Also, on the first day, we asked students about their expectations on the exercise course.

Table 2. Syllabus of an exercise course. Data type R shows raster data and V shows vector data.

Date	Sections	Main study topic	Software	Main data type
First	QGIS entry operations	Importing the spatial data to GIS, displaying an attribute table, styling a symbol, using a plugin, layout the map.	QGIS	V
	Downloading the GIS data	Downloading the free data from the Web site and converting to shapefile from xml using FGDV.	QGIS FGDV	V
	Merging and correction of spatial data	Creating the vector data such as points, lines and polygons. Merging the raster data and creating contour line from the DEM.	QGIS Ecoris DEM converter	V, R
Second	Spatial data conversion	Conversion of the spatial coordinates.	QGIS	V
	Basic spatial analysis	Measurement of features and processing an overlay analysis such as clip, union, intersect.	QGIS	V
	Network analysis	Shortest route searching between 2 points.	QGIS	V
	Region analysis	Buffering from vector features.	QGIS	V
Third	Point data analysis	Visualization of points density using grids and boundary polygons	QGIS	V
	Raster data analysis	Visualization of the topographic data and Calculating slope degree, slope direction, hill shade and terrain profile from DEM	QGIS Ecoris DEM converter	R
	Watersheds analysis	Extraction of rivers and basins.	QGIS GRASS GIS	R
	Spatial interpolation	Spatial interpolation using TIN and IDW methods	QGIS	V,R

RESULTS & DISCUSSION

Answers of students to each item in the questionnaire survey tended to be most positive on the second day and most negative on the first day. On the first day, most students used QGIS and spatial data for the first time in their life, resulting in the more negative evaluations than the other days. However, on the second day, students became familiar with QGIS and vector data, leading to positive evaluations. On the third day, the exercises included complex operations using both vector and raster data. In addition, the section of watershed analysis newly utilized GRASS GIS, which seems to have been difficult for the students because the ways of importing data and other operations are different from QGIS. For these reasons, evaluations on the third day were more negative than those on the second day, although they were still better than those on the first day.

As shown above, primary GIS users tend to give negative evaluations when exercises use multiple software packages and different types of data. Especially, if they use such software and data for the first time, difficulty tends to be high. If an exercise requires complex software operations and data processing, topics to be handled in a syllabus must be small in number. We also conducted cluster analysis to investigate the characteristics of the evaluations from the students. The result indicates that those with higher understanding and satisfactory levels showed a high expectation on the exercises even on the first day. This suggests a positive feedback and the importance of initial motivation of students. Therefore, we need to investigate how to increase the motivation of students for effective GIS education.

REFERENCES

Sadahiro Y, Ota M, Sato H, Okunuki K, Morita T, Kosaka H. 2012 Geographic Information Science Body of Knowledge. <http://curricula.csis.u-tokyo.ac.jp/bok.html>

Asami Y., Yano K., Sadahiro Y., Yuda M. 2015. Geographic Information Science GIS standards. Kokon Shoin.

Takahashi A, Okabe T. 2008. Classification and Characteristics of Students Taking a GIS Laboratory Teaching Course Using an Online Learning System. Journal of Geography (Chigaku Zasshi), 117(2), 354-369.