Learning with G-Portal: A geographic digital library.

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Abstract

Students learn Geographical concepts more effectively if they can identify and generalize about where
different resources or activities are spatially located and when they associate certain patterns and
processes with geographical changes. Digital libraries can be used to support web-based student-centred
inquiry as a mode of learning Geography. This study explores the affordances of a geographical digital
repository (the G-Portal) which organizes information around problem tasks. Two phases of the project
were to build a digital library for Geographical assets and to develop a place-name assignment algorithm
which automatically determines the names of places embedded in web pages referenced by these assets
so as to augment them with the appropriate location semantics. This G-Portal digital library serves an
active role in collaborative learning activities in which students conduct a virtual field study of an
environmental problem, within a geospatial context – in this case, beach erosion and sea level rise. G-
Portal also provides manipulation and analytical tools that can operate on the information retrieved.

Introduction

The World Wide Web today provides users access to extremely large number of web sites many of which
contain learning objects of high education value (Sumner & Marlino, 2004). Web pages may be designed as a set
of instructions that lead students in a procedural sequence to complete a learning task or they can be more open-ended
in that only the learning task might require the collation and interpretation of each page's informational
resources. As a global network of servers which enables user communities to create and share learning objects,
these resources may be organized in a manner which allows the users to select resources, choose ways of
representing and using the resources, create new resources and even develop their own learning strategies. The
G-Portal digital library project was initiated as an attempt

1. to improve on the existing capabilities of digital repositories and the move explicitly into multimodal
   representations, in that it hosts digital assets that can be used by students to solve an authentic problem
   based on real world resources.
2. to develop a place-name allocation algorithm that can potentially include generally available world wide
   web resources into G-Portal and enable searching based on spatial referents.

In order to effectively deploy G-Portal at local schools and test the effectiveness of the various capabilities of G-
Portal, a pilot project was conducted in two phases. Phase A examined the possible ways students could use G-
Portal to find information, create learning artefacts, construct arguments and explore their awareness of the
modality of information sources. In Phase B, the study investigated the important research challenge in digital
library systems - to provide the appropriate personalized project and query capabilities to satisfy the information
needs of users and applications. A personalized project can be seen as a sub-collection of digital assets
constructed during the learning journey of a student or a team of students. G-Portal provides tools for students
to manipulate information in these personalized projects and to create bookmarks for future references. For
many digital library collections, query-by-location works well when the objects to be retrieved can be specified
using query predicates on the object locations. For example, a user planning for a holiday trip in Korea may want
to find articles about Jeju, a popular resort island in the South of Korea. A student conducting beach erosion
research may want to find documents about beaches in California and Florida. For these query examples, the
complexity lies not in query evaluation, but in the extraction of location footprints from the documents. Unless
tagged by creators or other users, it is not easy to determine the spatial coordinates or locations of documents.
Besides query processing, place names appearing in documents can be used in applications such as:

1. Providing the location information of events described by the documents;
2. Enabling a map based visualization of documents; and
3. Mining spatial knowledge from documents or web pages containing both location and semantic concept information. For example, one may want to find the cluster of web pages related to healthcare in Minnesota.

In the G-Portal digital library project, we treat geography related web pages and other types of web objects as content resources and develop both map-based and classification-based interface to browse and query their meta-data records.

**Phase A: Capabilities of the G-Portal**

A range of capabilities that supports learners in their construction of geographical knowledge was created on the G-Portal. Among these features include:

*Project management.* Users can create a new project or personalise an existing project by specifying the basic attributes of the project including name, description, and whether the project is private. The user can also change these attributes or remove a personalized project. The concept of personal project space allows individuals to work in their personalized environment with a mix of private and public data and at the same time share part of the data with their team members, allowing students to explore and process the information, solve the problem posed and eventually construct a geographical understanding of it. Transduction of text into images or other modes of representation may also be possible within these personal projects.

*Built-in tools.* This includes some built-in tools such as zoom and measurement tools that allow the students to query the data spatially. Users can select data by non-linear methods and this encourages inquiry based on some analogy of the real world spatial context – the map. A certain degree of manipulation and consequent analysis of the data using these tools may support the learner in constructing meaning of the information.

*Layer management.* Within a project, layers can be defined to maintain resources in different logical groupings. Properties including name, description and type (resource layer or annotation layer) are specified for each layer. Within a personalized project, appropriate layers can be defined to group resources logically. Note that the layers and the assignment of resources to layers can only updated by the corresponding project owners. Indeed, the project layers emulate what a Geographic Information System does; it represents real world objects in layers. The information on each layer can then be used for comparison and analysis. For example, patterns may be described when objects across various layers are toggled “on” or “off”.

*Schema and resource management.* Every resource in G-Portal is created using a resource schema that serves as a template. In a personalized project, schemas can be user-defined to meet the needs of a learning activity for a user (or team of users). In a personalized project, resources are either entirely created by the user or copied from the other public projects, e.g. the master project created by a teacher for students’ reference. In a collaborative learning setting, it is also quite likely to have multiple users exchanging resources among their personalized projects. Essentially the schema and resource management allows the users to re-use objects that have been created by others. While recognising the degree of reliability may differ for object created by different users, such as instructors versus students, the reusability option may support student learning in that new meaning can be constructed out of existing pieces of information, represented as objects in this case.

*Personalized Project Export.* By providing each user a personalized workspace in G-Portal, the management of the resources (information) becomes much easier for each learning activity. This allows users to produce the object of the learning activity into a documented artefact.

The research questions that were asked in this study were crafted around these capabilities. Moreover, the way students use the portal in searching for information, processing the information and solving the problems posed to them will be limited and influenced by the way G-Portal is designed to be used.

**Method and approach**

The research question for Phase A was “How do students effectively learn Geography concepts while using the G-Portal in their task?” This research agenda focuses on the design of the application and G-Portal’s potential in
integrating and retrieving information for geographical task; and the ease with which students are able to undertake and complete studies of geographical phenomena. Given the research question, the issues of specific interest in terms of student processes included:

1. Usability issues — How do students use the G-Portal to find, retrieve, and create information about a Geographical task?
2. Search Strategies and retrieval techniques — Does the G-Portal support effective search strategies well?
3. Multimodality of representation — Can the students use tools within the G-Portal to represent information in various modes such image and numerical data?
4. Transduction of information — Can students more easily comprehend the data and its representation through the capabilities of the G-Portal which enable information to be changed from one mode of representation to another?
5. Representation of Geographical and Spatial Information — Does the G-Portal support students’ spatial understanding of the information?

In order to address these questions, a qualitative approach was used to describe how the students use the G-Portal for learning Geography. The students were given a task of using available geographic data to solve an authentic problem for a resort development consultancy. The detailed task is given in Error! Reference source not found. below.

Figure 1: Task given to the students to use G-Portal to solve a real life geographic problem.

As part of your familiarization with using the G-Portal, please complete the following task:
You have been asked to examine Profiles 6IV, 6V, & 6VI by a resort development to assess the state of this stretch of beach at ECP. In particular, why do you think the beach profiles looks different at different times of the year? Investigate this question using the G-Portal and other online resources. Present your report (using MS Word or MS Power Point or any other supporting software) to explain your findings. You should include visuals where necessary to illustrate your point. Visuals can be gathered from the G-Portal and from the internet. Remember that your target audience is the developer of the resort.

While working on the task speak aloud and verbalize your thoughts on what you are thinking or doing, what you are doing etc.

You will have 40 minutes to complete the report.

The research questions emphasised the students’ knowledge construction process but required, in addition, a fuller description of the learning activity. As the proposed approach to these questions was based on the learning ecology of design experiments (Cobb et al., 2003), the context of the activity was firmly placed within the discipline of Geography. Thus, the research and development team worked with some undergraduate students from a second year Coastal and Ocean Systems module at the National Institute of Education. This module traditionally requires the students to investigate a stretch of the local coast and solve some geographical problems resulting from the investigation. An introduction to the G-Portal was given at the beginning of the module. The students then accessed the information via the G-Portal throughout the semester.

The investigation by the students took place along a stretch of the east coast parkway coast of the island of Singapore. The main focus of the task was to identify and suggest possible coastline changes and the resulting impacts on the environment and land use of the study area. As students were performing this task, their use the G-Portal, together with a headshot of their faces was recorded into a single digital video clip. The footage was then viewed and a set of codes were generated (in relation to the research questions). The footage was then coded and the entire activity was then described using these codes.

The five research sub-questions were then rephrased into the following guiding questions to help the research team code the data.
1. How did students find information?
2. How did students form arguments in their discussion/artefacts?
3. Were the students aware of the modality of the information sources and artefacts?
4. How did the students construct artefacts?

After an initial viewing, the research team generated a generic set of codes. Finer details were added as the coding progressed. The codes generated followed the schema of Table 1.
Table 1: Coding scheme for the activity.

<table>
<thead>
<tr>
<th>Finding Information</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Navigation</strong></td>
<td><strong>Finding Information</strong></td>
</tr>
<tr>
<td>Using G-Portal Resources</td>
<td>Using G-Portal Resources</td>
</tr>
<tr>
<td>Using built-in tools</td>
<td>Using built-in tools</td>
</tr>
<tr>
<td>Schema and resource management</td>
<td>Schema and resource management</td>
</tr>
<tr>
<td>Search Engines</td>
<td>Search Engines</td>
</tr>
<tr>
<td>Search Type</td>
<td>Search Type</td>
</tr>
<tr>
<td>Keyword</td>
<td>Keyword</td>
</tr>
<tr>
<td>Phrase</td>
<td>Phrase</td>
</tr>
<tr>
<td>Query</td>
<td>Query</td>
</tr>
<tr>
<td>Direct URL</td>
<td>Direct URL</td>
</tr>
<tr>
<td>Search Result Navigation</td>
<td>Search Result Navigation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Forming Argument</th>
<th>To enable scientific activity, such as experiments and observations, to occur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure</td>
<td>Procedure</td>
</tr>
<tr>
<td>Investigation</td>
<td>Investigation</td>
</tr>
<tr>
<td>Sequential explanation</td>
<td>Sequential explanation</td>
</tr>
<tr>
<td>Theoretical explanation</td>
<td>Theoretical explanation</td>
</tr>
<tr>
<td>Causal explanation</td>
<td>Causal explanation</td>
</tr>
<tr>
<td>Information report</td>
<td>Information report</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Awareness of Modality</th>
<th>To describe, classify or define a number of classes, or parts, or attributes of a class of objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modality of source</td>
<td>Modality of source</td>
</tr>
<tr>
<td>Text</td>
<td>Text</td>
</tr>
<tr>
<td>Images</td>
<td>Images</td>
</tr>
<tr>
<td>Video or animation</td>
<td>Video or animation</td>
</tr>
<tr>
<td>Modality of artefacts</td>
<td>Modality of artefacts</td>
</tr>
<tr>
<td>Images</td>
<td>Images</td>
</tr>
<tr>
<td>Text</td>
<td>Text</td>
</tr>
<tr>
<td>Numerals</td>
<td>Numerals</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Constructing Artifact</th>
<th>To describe, classify or define a number of classes, or parts, or attributes of a class of objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piecing Information</td>
<td>Piecing Information</td>
</tr>
<tr>
<td>Text</td>
<td>Text</td>
</tr>
<tr>
<td>Images</td>
<td>Images</td>
</tr>
<tr>
<td>Video</td>
<td>Video</td>
</tr>
<tr>
<td>Position Montage</td>
<td>Position Montage</td>
</tr>
<tr>
<td>Students layout in artefact</td>
<td>Students layout in artefact</td>
</tr>
<tr>
<td>Source of information</td>
<td>Source of information</td>
</tr>
<tr>
<td>from G-Portal</td>
<td>from G-Portal</td>
</tr>
<tr>
<td>from web</td>
<td>from web</td>
</tr>
<tr>
<td>from prior knowledge</td>
<td>from prior knowledge</td>
</tr>
<tr>
<td>Work on Artefact</td>
<td>Work on Artefact</td>
</tr>
<tr>
<td>Copy and paste</td>
<td>Copy and paste</td>
</tr>
<tr>
<td>Cut n paste with formatting</td>
<td>Cut n paste with formatting</td>
</tr>
<tr>
<td>Writing and cut and paste</td>
<td>Writing and cut and paste</td>
</tr>
<tr>
<td>All the content written</td>
<td>All the content written</td>
</tr>
</tbody>
</table>

Note that not all the codes generated were observed, and the full structure was generated based upon the future possible comparison with post intervention data. For instance, while the web search type can be coded as keyword, phrase, query or direct URL searches, only the first two codes were observed in the current data set. The coding generated was based primarily on theoretical possibilities. All four types of searches are possible even if only two were observed. It would be incomplete to simply list two out of the four in the coding scheme. Furthermore, there are several further video clips that are being coded while this paper is being presented at the conference. The codes will describe alternative search patterns in those clips.

Furthermore, the analysis included the sequence and duration as each stage of the artefact was constructed. For Danny’s group, the learning artefact was a PowerPoint presentation and the time spent on creating each slide has also been included in the representations of the final construction. Cheng’s group however produced only one paragraph of explanation as their final product for the activity. In that case, the time spent on constructing the paragraph has been indicated on the representation. The codes were then plotted against the time spent on the activity to present a sequential overview of how the activity progressed. Not only does this allow the research team to describe in detail how each group used the G-Portal in the task, it also provides the basis for analysing the relationship between each coded segment of the activity.

Note that this conference proceedings may be used for private study or research purpose only.
Findings

The coded video clips of the learning activity are presented in Figures 2 and 3. To protect the identity of the subjects and in accordance with the ethical practise in research, the team has assigned pseudonyms to the two groups examined for this paper. Danny and Adirel, in the first group, worked on the task and produced a set of PowerPoint slides. Cheng, Yong and Win, three girls in the second group, produced a word document as their learning artefact. Essentially both groups agreed that there is a strong possibility of beach erosion at the east coast parkway in the short to middle term, and that the developers should serious consider against building a resort at the site. The “solution” provided is reasonable in that the students were correct in identifying the strong possibility of beach erosion given the data they can access from the G-Portal, and that resort development might not be feasible as erosion may disrupt or even damage structures erected at the site (due to erosion) and that the development itself may cause more environmental problems.

Information Finding

Based upon the video clips, students sought information either from within the resources on the G-Portal or the web. No additional sources of information, such as books or notes were used for the task. In particular, students used the built-in tools and the resource and schema management tools of the G-Portal; they also used only the keyword and phrase search types of the web search engine to source their information.

In Danny and Adriel’s case, they sought information in a “point and click” strategy using both the built-in tools (such as zooming in and out and point and click) and resource management tool and the web search engine. Using built-in tools started a couple of minutes into the activity and carried on for about 8 minutes. It was at this point that they started their web search for about a minute. Finding information using the G-Portal was also carried out in shorter than one minute intervals for constructing the third, fifth, seventh and eighth slides in their PowerPoint presentation. It seems reasonable to describe the information finding pattern as one in which information is found prior to the construction of argument and artefact. Indeed, they would find further information even as they are constructing their artefacts. In a sense they went “back” to the portal to find information sources to support their formation of arguments and creation of artefacts. In contrast, Cheng and her group members used the first two-thirds of the time to search for information and form arguments. The last twenty minutes was exclusively spent on constructing artefacts. Like Danny and Adriel, the group went back to the G-Portal to find information that they could use in their textual discussion and the formulation of their argument for the case. This group did not use other Internet sites at all.

Forming Arguments

Both groups were in continuous dialogue amongst themselves as they tried to solve the problem by analysing the information obtained from the resources on the G-Portal. In judging the quality of the arguments generated by the students, we define procedural arguments as those that enable scientific activity, such as experiments and observations, to occur. In other words, any set of procedures that help each group develop their argument or construct their artefacts. Investigation refers to an inquiry of, in order and with accuracy the aim, steps, results and conclusion of a scientific activity. Sequential explanation can be defined as arguments that explain how something occurs or is produced. When the groups seek to introduce and illustrate a theoretical principle and/or to explain events which are counter-intuitive their approach to argument can be termed as theoretical explanation. Theories may be scientific theories or personal theories in this case. While scientific theories introduce and illustrate a theoretical principle to explain events, personal theories explain such events through personal experience or beliefs.

Causal explanation tries to explain events for which there are a number of causes or factors. A more general approach of information report refers to how the discussion describes, classifies or defines a number of classes, or parts, or attributes of a class of objects. It also refers to a more general description of the phenomenon, issue or object.
### Finding Information

<table>
<thead>
<tr>
<th>Type of Navigation</th>
<th>Using G-portal Resources</th>
<th>Using built-in tools</th>
<th>Search Engines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Search Engine</td>
</tr>
</tbody>
</table>

### Using G-portal Resources

- Schema and resource management
- From G-portal
- From web
- From prior knowledge

### Using built-in tools

- Position
- Position
- Students layout on artefact
- Source of information
  - From G-portal
  - From web
  - From prior knowledge

### Search Engines

- Search Type
- Keyword
- Phrase
- Query

### Search Result Navigation

- Work on Artefact
- Copy and paste
- Cut n paste with formatting
- Writing and cut and paste
- All the content written

### Constructing Artefact (Slide No.)

<table>
<thead>
<tr>
<th>Piecing Information</th>
<th>Text</th>
<th>Images</th>
<th>Video</th>
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</table>

### Piecing Information

- Students layout in artefact
- Source of information
  - From G-portal
  - From web
  - From prior knowledge

### Work on Artefact

- Copy and paste
- Cut n paste with formatting
- Writing and cut and paste
- All the content written

### Forming Arguments

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Text</th>
<th>Images</th>
<th>Video</th>
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</table>

### Procedure

- Analysis
- Procedure
- Investigation
- Sequential explanation
- Theoretical explanation
- Causal explanation
- Information report

### Awareness of Modality

<table>
<thead>
<tr>
<th>Modality of source</th>
<th>Text</th>
<th>Images</th>
<th>Video</th>
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</tbody>
</table>

### Modality of source

- Text
- Images
- Video or animation
- Modality of artefacts
  - Text
  - Images
  - Numerals

### Modality of artefacts

- Text
- Images
- Video or animation
- Numerals

### Modality of artefacts

- Text
- Images
- Video or animation
- Numerals

### Forming Arguments

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</table>

### Procedure

- Analysis
- Procedure
- Investigation
- Sequential explanation
- Theoretical explanation
- Causal explanation
- Information report

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**Figure 2:** Coding of activity for Danny and Adriel

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**Figure 3:** Coding of activity for Cheng, Yong and Win
The two cases selected showed two different approaches to forming arguments in performing the given task. Cheng’s group created a learning artefact which is basically a paragraph of text. The group was involved more in procedure during the first 20 minutes of the activity in which they determined how they would find information to build their arguments and hence provide a solution to the question posed. Sequential arguments were presented early in the task (before 21 minutes) while investigation of the information found took place three times from about 20 minutes to 35 minutes into the task at short one minute intervals. This indicates a possibility that the students in this group tried to explain the chronological development in the profiles first, and then investigating the possible reasons for the observed patterns. They then formed most of their theoretical and causal arguments towards the end of the task (from about 35 minutes to 62 minutes). The main reasons stated for their arguments are derived from the theoretical and causal arguments. Indeed, the following quotation comes from the artefact:

“There is a great deal of information available on the G-Portal and from the web. Given that Cheng’s group sought information only during the earlier part of the task, it was not unexpected to find that the coding for awareness of modality in source coincided with their information finding phase. They mostly used visual images from the G-Portal and tried to cut and paste some of the images on their artefacts. However, they only used these images at the beginning to their artefact and is not referred to in the written text. The artefact was therefore represented as images from about 6 to 12 minutes but represented as text from 40 minutes till the end of the task. The visual modes of representation in the information was apparently transducted into textual explanation of their arguments and suggested solutions to the question posed. This can be further discussed in the next section on constructing artefacts.”

In Danny and Adriel’s case, procedure was determined early in the task from about 5 minutes to 9 minutes into the task. This was preceded by some investigation of the data. In other words, the students “played around” with the G-Portal and investigated the information sources before commencing on the task by determining their approach. Also investigation, sequential, theoretical and causal explanations were given for each of the slides on which they provided some “solutions”. Unlike the previous group that left the analysis and explanation to the end, the group found information, formed arguments and created artefacts on a slide by slide basis. They ended the slides by giving an information report on what they have decided on and provided the advice that “Overall, the beach is highly vulnerable to erosion and thus it is not advised that resort development should be carried out”. Certainly one could argue that this is due to the nature of the software application used (MS Word for Cheng’s group and MS PowerPoint for Danny’s group). However, there is a clear difference in their awareness of modality between the two groups. Danny’s group for example relied more on visual resources and created artefacts rich in images while Cheng’s group used only text in their artefact.

Awareness of Modality

Modality refers to the mode in which information is represented. In this case, both the resources and the artefacts produced by the students can be represented in various modes such as text, images or even videos and animation. One of the general conclusions available from current research is that, while multimodal text analysis has advanced significantly over the last fifteen years (Jewitt & Kress, 2003), there is now a need to move from a description of the structure and meaning-making potentials of multimodal texts, to a detailed description of how learners can and do those potentials in everyday education settings.

Modality in sources refers to an awareness of the modes of representation in the information sources on the G-Portal or from the web. Given that Cheng’s group sought information only during the earlier part of the task, it was not unexpected to find that the coding for awareness of modality in source coincided with their information finding phase. They mostly used visual images from the G-Portal and tried to cut and paste some of the images on their artefacts. However, they only used these images at the beginning to their artefact and is not referred to in the written text. The artefact was therefore represented as images from about 6 to 12 minutes but represented as text from 40 minutes till the end of the task. The visual modes of representation in the information was apparently transducted into textual explanation of their arguments and suggested solutions to the question posed. This can be further discussed in the next section on constructing artefacts.

Danny’s group showed that they only used information as represented by images from the G-Portal and the web. They even found a panorama movie of the site from the G-Portal. However, the artefacts were a mixture of text and images. There were two instances whereby numerals were used. This was when a rate of erosion was calculated and typed on the slides. Certainly the final conclusion was written as text format and the students used various visuals from the G-Portal to piece together the final artefact. While Danny’s group used more than one mode of representation in their final artefact, compared with Cheng’s group, the situation may be described as employment of multimodality. Hence, Danny’s group showed more evidence of multimodality.

Constructing Artefacts

Danny and Adriel’s group spent most of the time on their task constructing artefacts. Indeed, they were working through the artefacts while they found more information or while they discussed the arguments for the case.
Cheng’s group, on the other hand, mainly constructed their artefacts only towards the last 20 minutes of their task, while spending most of the time before 42 minutes into the task.

In terms of piecing together information, or the kind of content types they choose to use from the sources, Cheng’s group only used image resources from the G-Portal on two occasions. Cheng’s group was the only group who in one instance positioned a montage where students positioned and formatted modes for presentation (using resize and positioning of the image). While this is a rather limited employment of multimodality, there is an irony that the group decided to abandon the processed images for a more text-based approach. In contrast, Danny’s group used text as well as images from the G-Portal to construct their artefacts.

While Cheng’s group only used sources from the G-Portal in constructing their artefacts, Danny’s group also used the web in a couple of instances. In particular, the information was represented as images. They used the image from the web in the introduction slide, more to decorate the slide than to achieve any other purpose. Hence it cannot be considered as an employment of multimodality. However, Danny’s group used images of the profiles to support the arguments that they propose on the slides. In particular, each slide with a profile image was followed by a slide of explanation.

Working on artefact refers to whether the students used the content they take from a source, the extent the students synthesize the information to fit to an appropriate answer to the task and whether the students write additional content. Cheng’s group initially copied and pasted some images of profiles from the G-Portal onto their artefact (about 7 to 11 minutes) but decided to leave the explanation to the end, in the form of a written paragraph. Hence there is no apparent transduction of modes of representation here until the end of the task where the analysis of the images and the arguments formed resulted in a piece of text.

Danny’s group copied and pasted some images of the profiles in their artefact. There were two instances in which they calculated the approximate rate of erosion from the images of the profiles. There is clearly transduction of information from a graphical mode to a numerical mode (at about 20 and 38 minutes into the task). The rest of the artefact was written in text based on the arguments they have formed after analysing the information from the G-Portal. Hence Cheng’s group showed very limited employment of multimodality while Danny’s group showed that at least three modes of representation was present, namely, text, numerals and images.

**Summary and Discussion of Phase A**

In terms of finding information, the students used only the built-in tools and the resource and schema management tool of the G-Portal. While one group showed that they did use the web to find additional information, it was primarily to find an image they could use to decorate their introductory slide. This presents the development some challenges. For example, the absence of use of other G-Portal capabilities such as personal project management and layer management may indicate that these capabilities are not easily accessible to the user. These are areas that the user interface could be improved on.

It can be argued that the software application that the students choose to construct their artefacts influences the way they approach the task. For example, Cheng’s group chose to use MS Word and this lead to more discussion on the procedure followed by analysis then theoretical and causal explanation for their solution. Danny’s group used MS PowerPoint and this led to theoretical and causal explanations after each beach profile was analysed. Certainly, a counter-argument could be the antecedent learning styles of the two groups of students. This is an area about which further research can be conducted.

While Danny’s group used three modes of representation, namely text, numerals and images, Cheng’s group only created one piece of text artefact with three diagrams that have not referred to. Again this can be attributed to the application chosen and its affordance on the way information can be represented. This becomes clearer upon examining the way the students created their artefacts in that Cheng’s group mostly “wrote” their learning artefact while Danny’s group copy and pasted images, calculated rates of erosion and “wrote” explanations.

As a preliminary study, the analyses of the artefacts suggested that the G-Portal was useful to some extent in providing resources to support the students in finding information. There is evidence that at least one of the two groups was able employ multimodality in the construction of their learning artefacts and that the way students approached the task was determined to some degree by the software application they chose to work with.
**Phase B**

Among the web pages dealt by G-Portal, many of them contain location information that could provide useful spatial footprints for query processing. Our research identifies at least three place name semantics that can be adopted. The first place name semantics refers to the host location of the web page. This can be determined mainly by the domain name of the web page URL and can usually be carried out quite easily. There should only be one such location for each web page. The second semantics refers to the places described within web pages, e.g., a web page describing beaches in Hawaii. The third semantics refers to places as attributes of some events or objects, e.g., a web page describing a terrorist bombing event in Jakarta where Jakarta is the place attributes.

Since our research deals with mainly geography related web pages, we adopt the second place name semantics. The identification of place names of the second and third semantics clearly requires content analysis. It is however noted that the extraction of place name attributes for events and objects is usually covered in the named entity extraction task. The extraction techniques for place names with the third semantics can also be used for place names of the second semantics but there are other issues to be addressed for the latter.

Therefore, unless otherwise stated, place names in our research are of the second semantics. In this phase of the study, we aim to address the place name assignment task for geography-related web pages. While most of present studies on place name assignments focus on the way place names are extracted and disambiguated, they have not explored how place names found in a web page can be used to determine the place names to be assigned to web pages and web page segments which are also known as the page level and segment level place name assignment problems respectively. Since a page is also a web page segment, we shall simply use place name assignment to mean both page and segment level place name assignments in this paper. Indeed, place name assignment problem has to be solved in order to identify place names of the second semantics, and to filter away place names of the third semantics. In place name assignment, the accuracies of extracting and disambiguating place names are clearly important. There are in addition two challenging research issues:

- **Granularity** - A gazetteer consisting of place names is usually used to identify the place names occurring in a web page. Other than filtering away place names of third semantics, one has to assign place names at the appropriate granularity level as place names can be related to one another by containment (or parent-child) relationship. For example, New York city is part of New York state which is in turn part of USA.

- **Relevance of place name to content** - The goal is to accurately determine the segments where some places are the foci of description within them. An over-sized segment will be undesirable, as it does not direct reader's focus to the most relevant part describing a place name. An under-sized segment, on the other hand, will miss parts of web page that are relevant.

We define the place name assignment task as consisting of three sub-problems, namely place name extraction, place name disambiguation and place name assignment. Place name extraction refers to identifying the place names appearing in web pages. The extracted place names provide the input to place name disambiguation. Disambiguation is necessary as each extracted place name may not have a unique match with some pre-specified dictionary of place names which is often known as a gazetteer. Without a unique match, the spatial location and type of the extracted place name cannot be determined. In place name assignment, each web page or web page segment is assigned zero or more place names when the corresponding places are significantly described by the page or page segment. We have chosen a collection of web pages referenced by DLESE for this research (Digital Library for Earth System Education, 2005). The collection is chosen because many of these web pages contain place names and it is conceivable that the assigned place names will allow them to be spatially browsed and queried in G-Portal.

In the following, we summarize our contribution to the place name assignment task:

- **Place name extraction**: We use the well known General Architecture for Text Engineering (GATE) named entity extraction tool to extract place names from web pages (GATE can be downloaded from http://www.gate.ac.uk). A new gazetteer containing mostly USA place names has been constructed and it allows GATE to easily extract place names from DLESE web pages.

- **Place name disambiguation**: A new place name disambiguation method based on heuristics rules has been developed. It consists of several steps each applying different set of rules to disambiguate place names. Our experiments have also shown very good disambiguation results.

- **Place name assignment**: A new place name assignment method for both page and segment levels has been proposed. The method incorporates the place name hierarchy in the given gazetteer to help assigning the most appropriate place name(s) to a web page or page segment.

We have conducted some experiments to evaluate our disambiguation and place name assignment methods on randomly selected DLESE referenced web pages. A set of performance metrics have been defined. The results have been encouraging and it was found that geo/nongeo ambiguities adversely affected our place name assignment. In this study, we assume no training dataset is given and human subject is used only during the
evaluation phase. We also assume that a gazetteer consisting of place names organized with parent-child relationships is given.

**Experimental Results**

In this section, we describe the experiments conducted to evaluate the accuracy of our place name disambiguation method and place name assignment method on a collection of web pages created from the DLESE metadata collection (Digital Library for Earth System Education, 2004). For place name assignment, we first introduced the evaluation metrics for both page-level assignment and segment-level assignment. We have conducted the evaluation on a set of 50 web pages randomly chosen for manual checking for page-level assignment. The same was done for segment-level assignment. As only an US gazetteer was used, in our experiments, we focused only on US place names.

**Dataset**

In our experiment, the DLESE dataset was created by downloading web pages referenced by DLESE metadata records. DLESE is an ongoing NSDL digital library project that gathers metadata of earth science related web objects including web sites, web pages and other types of files. Thirty concurrent crawler threads were used and they were programmed to skip files with extensions .doc, .gif, .jpg, .mov, .mpg, .pdf, .xml and .ppt. Most of the downloaded web pages have extensions html, htm and txt. As shown in Table 2, a total of 8726 web pages were finally included in the DLESE dataset, and they are referenced by 8835 metadata records. Note that there could be more web pages downloaded by following the links in these DLESE web pages. As their relevance to geography content cannot be easily determined, we have chosen not to include these indirectly referenced web pages. Table 3 lists the top five web sites referenced by DLESE metadata records. Together, they contribute more than 30% of the web pages. This information may be useful if site-specific semantics can be later incorporated to handle web pages of these popular web sites.

<table>
<thead>
<tr>
<th>Total number of DLESE metadata records used</th>
<th>8835</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of distinct URLs</td>
<td>8726</td>
</tr>
<tr>
<td>URLs referenced by multiple resources</td>
<td>109</td>
</tr>
<tr>
<td>Number of distinct web sites</td>
<td>2218</td>
</tr>
</tbody>
</table>

**Table 3: Top 5 Web hosts**

<table>
<thead>
<tr>
<th>Web host (Web site)</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>svs.gsfc.nasa.gov</td>
<td>2091</td>
</tr>
<tr>
<td><a href="http://www.nationalgeographic.com">www.nationalgeographic.com</a></td>
<td>168</td>
</tr>
<tr>
<td>www2.nature.nps.gov</td>
<td>129</td>
</tr>
<tr>
<td><a href="http://www.ucmp.berkeley.edu">www.ucmp.berkeley.edu</a></td>
<td>128</td>
</tr>
<tr>
<td>serc.carleton.edu</td>
<td>116</td>
</tr>
</tbody>
</table>

**Evaluation of Disambiguation Method**

As there are 8835 web pages directly referenced by DLESE metadata records and place names in them have not been manually labelled, we have randomly chosen 50 pages containing more than 31 and less than 200 occurrences of place names from the collection and evaluate our place name disambiguation method on them. The place names of these web pages were first extracted using the GATE extraction method. In place name disambiguation, a place name can either be correctly or wrongly disambiguated. For the wrongly disambiguated place names, we consider two types of errors: geo/geo and geo/non-geo. A geo/geo error refers to a case where the extracted named entity is a place name but an incorrect place name is assigned. A geo/non-geo error refers to a case where the extracted named entity is in fact not a place name, but has been assigned a place name during disambiguation. Unfortunately, geo/non-geo errors cannot be recognized in our disambiguation method as our method assumes that the named entities extracted from GATE are some place names.

For the 50 randomly chosen web pages in our experiment, after eliminating the 1185 non-US named entities (no possible matches with US places), there was a total of 1387 named entities, and 760 of them were place names. Among the 760 extracted place names, we found that 676 have been correctly disambiguated by our method,
giving a precision of 88.9%. This was done by manually checking the 760 disambiguated place names. Among the 676 correctly disambiguated place names, the contributions of different heuristic rules are tabulated in Table 4. The result shows that Perfect Matching is the most effective rule in our experiment, and more than half of the correctly disambiguated place names were obtained from this rule. Spatial Distance-based heuristic rule also plays an important role in disambiguation, contributing to almost one third of correct disambiguation. Propagation of the disambiguated place name senses does not help too much, probably due to the fact that it is carried out after the Self-Feature rule is applied. A more detailed explanation of the various heuristic rules can be found in Zong et al (2005).

<table>
<thead>
<tr>
<th>Rule</th>
<th>Places disambiguated</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Feature Extraction</td>
<td>96</td>
<td>14.2%</td>
</tr>
<tr>
<td>Perfect Matching</td>
<td>354</td>
<td>52.4%</td>
</tr>
<tr>
<td>Propagation of place name senses</td>
<td>24</td>
<td>3.6%</td>
</tr>
<tr>
<td>Spatial Distance-based</td>
<td>202</td>
<td>29.9%</td>
</tr>
</tbody>
</table>

Table 4: Contribution of heuristic rules

Evaluation Metrics for Place Name Assignment

We have adopted two metrics for evaluating the performance of our place name assignment algorithm. The first metric, page-centric accuracy, is for evaluating the performance of assigning place names to the pages in page level place name assignment. The second metric, known as place-centric accuracy, measures the degree of accuracy of assigning a place to a particular segment in segment level place name assignment. For the page level place name assignment, a human subject is given a set of pages and a place assigned to each of them. He or she is expected to give one of two possible responses at his/her discretion for each page:

A: The place name assignment is correct for the page.
B: The place name assignment is not correct for the page.

The page-centric accuracy is thus defined by

$$\text{Page-centric accuracy} = \frac{#A}{#A + #B}$$

To measure the performance of segment level place name assignment, a human subject is given a segment s and a place name p assigned to it. He or she is expected to tell to what degree the segment can be assigned with the given place. One of four possible responses will be given at his/her discretion for the segment-place name pair:

C: The assignment of p to s is completely wrong – For example, p and its child place names does not appear in s at all.
D: The segment s is too large to be assigned with p – In other words, p is relevant to s but some parts of s should be excluded.
E: The segment s is too small to be assigned with p – In other words, adjacent parts of s that are also about p are not included in s.
F: The segment s is just about the right region to be assigned with p - This is the most ideal situation indicating that the assignment is good.

It should be noted that responses D and E naturally involve some degree of tolerance, subject to the human subject. If the segment s is way too large or too small to be assigned with place p, the human subject should respond with C instead. That is, the assignment should be considered as wrong if it is beyond a certain degree of tolerance. We further define two accuracy measures for place-centric metric as shown below:

$$\text{Hard accuracy} = \frac{#F}{#C + #D + #E + #F}$$

$$\text{Relaxed accuracy} = \frac{#D + #E + #F}{#C + #D + #E + #F}$$

Obviously, relaxed accuracy is greater than or equal to hard accuracy, as it relaxes the criteria for the “right” region. Relaxed accuracy is designed to give more weight to correct place name than the correct segment.

Experimental Results for Place Name Assignment

In the experiment for both page level and segment level place name assignments, we assigned the best place name to each web page. For page level place name assignment, a random sample of 50 pages was chosen. A human subject was then asked to give his/her responses to each of these pages and their page name assignment. As depicted in Table 5, 33 out of 50 page level place name assignments were considered correct, and 17 were
incorrect. This gave a page-centric accuracy of 66%. When the incorrect assignments were examined further, it was found that 12 of them were in fact due to geo/non-geo errors during disambiguation. As our assignment method does not really deal with geo/non-geo ambiguities, it did not perform well. We therefore evaluated the performance of our place name assignment algorithm again with geo/non-geo errors discarded and obtained a page-centric accuracy of 33/(50−12) = 86.8%. For evaluating the accuracy of segment level assignment, another random sample of 50 pages was chosen, with each page having the place with highest score assigned to a segment and the segment-place pair identified. A human subject was given these pages and asked to give his/her responses to each of the segment-place pairs. As shown in Table 6, assignment at segment level for 29 pages was considered totally wrong, 3 pages with segment being too large, 3 pages with segment being too small, and 15 pages with segment being just right. Again, further inspection shows that 27 out of the 29 pages were due to geo/non-geo errors, and 2 of them were actually assigned with wrong places. Discarding pages with geo/non-geo errors, the hard accuracy for the place-centric metric is 15/(50−27) = 65.2%, relaxed accuracy (3+3+15)/50−27 = 91.3%.

Table 5: Performance for page level assignment

<table>
<thead>
<tr>
<th>Response</th>
<th>Entity category</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>geo/geo</td>
<td>33</td>
<td>66%</td>
</tr>
<tr>
<td>B</td>
<td>geo/geo</td>
<td>5</td>
<td>10%</td>
</tr>
<tr>
<td>F</td>
<td>geo/non-geo</td>
<td>12</td>
<td>24%</td>
</tr>
</tbody>
</table>

Table 6: Performance for segment level assignment

<table>
<thead>
<tr>
<th>Response</th>
<th>Entity category</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>geo/geo</td>
<td>2</td>
<td>4%</td>
</tr>
<tr>
<td></td>
<td>geo/non-geo</td>
<td>27</td>
<td>54%</td>
</tr>
<tr>
<td>D</td>
<td>geo/geo</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>E</td>
<td>geo/geo</td>
<td>3</td>
<td>6%</td>
</tr>
<tr>
<td>F</td>
<td>geo/geo</td>
<td>15</td>
<td>30%</td>
</tr>
</tbody>
</table>

The hard accuracy for the place-centric metric turns out to be a very strict measure. Not only does it require the correct assignment of a place with high confidence, it also requires the “right” region to be assigned together with the place. In fact, deciding the “right” region is more subjective than deciding the correct place as it depends on the organization of the content of a page in addition to readers’ discretion. In our experiments, we have only considered the segment assigned with a place with the highest score across the whole page. It could be the case that a particular assignment can apply to a larger region but with a reduced confidence, which is what response E indicates. On the other hand, it could be the case that related places are mentioned in some parts of the segment, all contributing some score to the assigned place, but there is one portion mentioning the assigned place more intensively. This may lead readers to conclude that the place is assigned a region that is too large, which is what response D indicates. It should be noted that in the page-centric metric, we do not consider such cases, and the focus is on whether the assignment of a place to a page makes sense. By relaxing the “right” region criterion, the relaxed accuracy value (91.3%) is consistent with the page-centric accuracy value (86.8%). It should also be noted that most wrong assignments both at page level and at segment level are due to geo/non-geo errors, which is not handled by our place name assignment method. It hence suggests that to achieve better assignment accuracy, geo/non-geo errors have to be eliminated at the place name extraction and disambiguation phases.

Discussion

Phase B of this paper describes the task of assigning place names to geography-related web pages so as to discover more semantics about the web pages. We focus on two important sub-problems in the task, i.e., place name disambiguation and place name assignment. We devised a rule-based disambiguation method that used self-features, near context, perfect match, extraction patterns, and spatial distance to systematically determine a gazetteer place name to each ambiguous place name. The method achieved good precision for a random sample of 50 web pages referenced by DLESE metadata records. We have also proposed a place name assignment method that considered the contributions of child place names during the assignment. This assignment method has been evaluated using both page-centric and place-centric accuracies designed for evaluating page level and segment level place name assignments respectively. Although we have obtained some interesting results, much more research remains to be investigated and we highlight two below:

- There are more extensive experiments that should be conducted to evaluate our proposed place name disambiguation and place name assignment methods. Due to time constraint, the current evaluation has been done on a small set of web pages and has not included other possible methods.
We have noted that geo/non-geo ambiguities contributed significantly to the errors made by our methods. We therefore plan to extend our place name disambiguation method to handle them.

**Conclusion**

Both phases A and B of the study examined the learning and development aspects of the G-Portal project, respectively. In Phase A, we have found that the G-Portal provided resources to support the students in finding information to some limited extent. There is evidence that at least one of the two groups was able employ multimodality in the construction of their learning artefacts. In addition, that the way students approached the task was determined to some degree by the software application they chose to work with. There is little use of other capabilities of G-Portal by the students and this could indicate that the design and usability of the G-Portal has to be improved to provide these support in a more affordable manner.

Phase B of the study showed that while the place name disambiguation and place name assignment methods worked well with our small sample, there is a need to expand this research area to reduce the geo/non-geo ambiguities which contributed significantly to the errors in this study.

The results from both phases indicate that the G-Portal has immense potential to be developed further at least in two areas:

1. Improving usability and support for learners using G-Portal as a learning tool to gather information in solving geographical problems.
2. Improving place name disambiguation and assignment methods so as to expand capability of G-Portal to provide spatially tagged information for learners to solve geographical problems.

Indeed, an extension of the project into a Meta-Portal project is underway to tackle these two issues. It is essential to recognise that a digital library that organises information within some spatial context is not sufficient to ensure that it can support learners in solving geographical problems. The usability as well as the ability of the G-Portal to capture and organise current web resources, developed in step, are necessary in providing the user the tools to solve the geographical problem posed.

**References**


