FP7 Project nr 226487 Project start date: 01 May 2009
Acronym: EuroGEOSS
Project title: EuroGEOSS, a European approach to GEOSS
Theme: FP7-ENV-2008-1: Environment (including climate change)
Theme title: ENV.2008.4.1.1.1: European Environment Earth Observation system supporting INSPIRE and compatible with GEOSS (Global Earth Observation System of Systems)
Web site: www.eurogeoss.eu

D2.5.3: Report on user study for the Natural Language Discovery and Query Interface

Title	D2.5.3: Report on User Study for the Natural Language Discovery and Query Interface
Creator	Claudia Cialone, Kristin Stock
Creation date	04/04/2012
Date of last revision	13/04/2012
Subject	Query Interface, Natural Semantic Metalanguage, User Study
Status	☒ Final
Publisher	EuroGEOSS
Type	Text
Description	Natural Language/Semantics Research, Discovery Interface Implementation and evaluation phase
Contributor	Claudia Cialone, Kristin Stock (CGS, University of Nottingham)
Format	Word document.
Source	
Rights	☐ Restricted ☒ Public
Identifier	D2.5.3: Report on User Study for the Natural Language Discovery and Query Interface.doc
Language	En
Relation	WP2
Coverage	Not applicable

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ACRONYMS AND ABBREVIATIONS

Abbreviation	Name
GUI	Graphical User Interface
JRC	Joint Research Centre
SBA	Societal Benefit Area
WP	Work Package
WPS	Web Processing Service
NSM	Natural Semantic Meta-language
GEOSS	Global Earth Observation System of Systems
GIS	Geographic Information Systems
SUS	System Usability Scale

1 INTRODUCTION

The main scope of this report is to give an update and conclude the implementation phases for the Natural Language Query Interface (NL Query Interface) by presenting a final user evaluation of the interface followed by relevant results after its implementation.

This report is structured as follows. Section 2 describes the user study and the results. Section 3 explains the overall progress of Task 2.5 up to the end of the project. Section 4 concludes the report. In Appendix 1 is a list with the disseminations for Task 2.5 from the start of the project.

Readers who are interested in technical specifications of the architecture, semantic structures, data models and protocols adopted during implementation of the Natural language query interface may refer to the previous reports that have been prepared - Deliverable 2.5.1 and Deliverable 2.5.2, by the University of Nottingham.

2 USER STUDY

The user study was conducted in two parts, each distinguished by its methodology, the number of participants and by the typology of the results obtained.

The first part of the user study revolved around a qualitative analysis of our interface with a few participants based on an assessment of its multilingual ease and semantic intuitiveness; whereas the second part delved into a quantitative investigation with a higher number of participants, focussing on the user's appreciation of the interface in comparison to a more traditional Geographic Information System (GIS) interface approach, ARCGIS10. [1]

2.1 Part 1 User Study: Qualitative Method

In the first part of the user study, our goal was to allow participants to use the interface by asking them to accomplish some specific tasks. They had to reflect on the tasks assigned without feeling the pressure of having to accomplish a task quickly, and to express their ideas about their experience openly. Individual tests were conducted and lasted about 45 minutes for each participant but in some cases less depending on the degree of IT expertise they had (for example 2 computer programmers involved in the study seemed to have a quicker response to the task of writing a query even if they had never seen our interface before). After the individual tests, a discussion group was held revolving around the issue of how the user would improve the interface based on his/her experience with it.

The study was conducted at the EuroGEOSS general conference in Madrid (25-27 January 2012) and was advertised by the organizers of the conference, through fliers and email to all the participants.

The participants to this part were not in such a number to justify a quantitative study but they constituted a good base for a qualitative investigation as a launching pad towards a quantitative analysis. The goal of this part of the user study was to conduct in-depth interviews in order to gain a deep understanding of the views of participants, rather than to make numerical generalisations across populations. They were 13 participants of which, 7 were Spanish, 4 were Italian, and 2

[1] ArcGIS10 ESRI Website: http://www.esri.com/software/arcgis/arcgis10/index.html

English. Their background varied from computer programming to geography, from cartography to biology and oceanography.
The user interface is designed to allow users to express spatial queries. In order to allow the participants to make their own evaluation of a particular spatial relation and how to describe it, we used a set of 4 sketches showing geospatial scenarios.

The methodology was as follows:

1. Participants were asked to describe what they saw in the sketch using their own natural language although a little help was needed from the experimenter as they did not understand straight away what kind of description they had to give.

2. A practical task performed with the interface, in which participants had the time they needed to express the same spatial concept prompted by the images using the lists of Geographic features (these being ontologies, controlled vocabularies and thesauri) to represent the geographical objects depicted (e.g, a river, a forest) and choosing a word or a combination of words from the NSM list to represent the spatial relation between them (NEAR, FAR, INSIDE).

3. Users were asked to select words using the Microsoft Desirability Toolkit (MDT) from which the participant had to underline the final 5 that best represented their experience with the interface.

4. Open Interview. The final section of the experiment involved asking 3 questions to which the users could answer openly. The questions were:

   a) How did you feel about describing the picture you were given using the interface? Did you find it flexible or was it difficult? And Why?

   b) Given the images assigned to you, do you think there were other things you wanted to express that could not be described using this table of words?

   c) Is there anything you particularly liked about the experience of describing the image with the interface?

5. Finally the group discussion included three questions about the users appreciation of this interface, but most of all, given them the possibility to do so, how would he or she correct this interface to make it more accessible to his/her own interests or usable in general.

The location of the experiment was a room in a conference centre in Madrid, Spain during the EuroGEOSS general conference where each participant was tested individually.

Instructions were translated from English into Spanish and Italian in a way that they meant the same across the three languages. Experiments were conducted entirely in the language of the participant.

The material adopted to carry on the experiment consisted of:

- Handmade pictures, used to perform the diagrammatic section of the experiment.

- Blueberry FlashBack Software, used to record voice, keystrokes and screen of the participant.[2]

- Finally the experimenter was taking notes for the whole duration of the experiment and asked questions during the interview until depth of understanding was achieved.

2.1.1 Results Part 1 User Study

Figure 1: Word Cloud of MDT recurrence

As can be seen from the word cloud in figure 1 above describing people's appreciation of the interface, it seems there is a shared feeling (more than a half of the participants) that the interface is **rigid** (see also Appendix 1 below). It was also less strongly identified as accessible and intuitive.

The following points summarize the answers obtained by the participants to the questions asked in the in-depth interviews.

a) According to 5 GIS experts notwithstanding the initial rigidity, in comparison with other GIS approaches, this interface could be particularly apt for non-experts use but also as a tool for GIS experts performing a preliminary geospatial search. In any case, none of the users seemed to deny its usefulness. An added value is its accessibility because it can open up novel ways for a new generation of GIS multilingual interfaces.

b) As far as the search is concerned, the NSM language was quite difficult to use for its morpho-semantic (the meaning of the words) limitations. People needed a considerable amount of time to read the terms the first time and quite a few creative ideas to be able to represent the spatial relations in their mind using these words. However many participants asserted that the more the familiarity with the NSM language the more accessible and usable, but with the difference that people can express spatial relations without having to learn the geometrical technicalities behind standard forms of GIS Interfaces. Furthermore, the mixture of technical (e.g., GEOSS parameters) and less technical vocabularies (GEMET as a general thesaurus) providing geographic features

[2] http://www.bbsoftware.co.uk/

between which a spatial relation in NSM is expressed, might give a wider audience of users the possibility to utilize this interface.

2.2 Part 2 User Study: Quantitative Method

In part 2 of the user study, 80 participants evaluated both the Natural Language NSM interface and a more traditional GIS approach developed by ESRI, ArcGIS 10[3] to accomplish similar tasks. Again the participants were not given time limitations as our aim was not to test the speed of the interfaces but their appreciation and intuitiveness.

The study was conducted in a lab at the Nottingham Geospatial Institute at the University of Nottingham (26-30 March 2012).

The experiment was advertised through emails, fliers spread to all the faculties, and departments of the University of Nottingham (but also to personal acquaintances, gym and climbing centres in Nottingham).

The participants to the experiment 80 of which 14 did not give valid responses and were excluded, the remaining were mainly students aged between 18-25 years old, whose studies spanned from business/economics to psychology, from zoology to mechanical engineering, from French, Chinese Spanish studies to nutrition etc. A few were lecturers or researches for the University of Nottingham.

The methodology adopted was as follows:

1. Participants were provided with a demo of the first interface, including a practical example.

2. Participants were given 2 sketches and asked to formulate queries. Then, while for our interface they needed to chose a word or a combination of natural language words from the NSM list to represent the spatial relation between them (NEAR, FAR, INSIDE) as in part one of the user study; in ArcGIS they needed to perform a GIS query using ESRI spatial relations.

3. -At the end of their tasks with each interface they had to compile an evaluation sheet. This was a 10-item psychometric scale, the System Usability Scale or SUS. Notwithstanding the simplicity of the scale, this is a fairly easy psychometric evaluation and good for our purposes. It accommodated our aim to evaluate the ease-of-use of the two interfaces (Tullis et al 2004, Lewis & Sauro 2009, Sauro 2011).

4. In addition to the SUS scale, participants were asked to answer to 2 questions to which the users could answer openly. The questions were:

    a. Which of the two query interfaces did you like most and why?
    b. Which interface do you think is more intuitive for a geographical search? Why?

5. In order for the participants to know the functionalities of both interfaces they were provided with two demos where a practical example of how to perform a query with each interface was illustrated in simple steps.

[3] ArcGIS10 Esri Website: http://www.esri.com/software/arcgis/arcgis10/index.html

Since the two interfaces were in two different formats (a web app. and a software package) and since demos and paper instructions were needed, in order for the whole experiment to be possible, the experimental procedure was made multimodal. Participants in fact had to switch from paper aid to virtual slides to hyperlinks to the interfaces. They had to follow a set of paper instructions where they were guided through the experiment to a 'task slide' on their screens showing the links to the appropriate interfaces and demos in alternate sequence (40 had to start analysing our interface, the rest started from the ArcGIS one).

The location of the experiment was the Imagery & remote sensing laboratory in the Nottingham Geospatial Institute at the University of Nottingham, in UK, where each participant was allocated to a computer station with ArcGIS and the NL Interface set in it and could work quietly on his/her own.

The experiment was not recorded by any software. The material analysed was constituted by:

-paper instructions
-virtual task slides (to follow the links)
-computers to perform the task
-pictorial cards to accomplish to the spatial task
-a file with documents containing the evaluation sheets (psychometric scales and open questions), and the demographics of the participant.

2.2.1 Results Part 2 User Study

The results collected from part 2 of the user study were of different nature:

- open answers to open questions
- statistical response to the SUS.

We will take this up in order and then discuss the results more generally in section 2.3 below.

Results : Open Questions

The open questions were mainly focused on a comparison between the two interfaces based on appreciation and intuitiveness. A general trend from a first analysis of the answers to the open questions proposed in the study shows that a vast majority of participants seemed to like the ArcGIS interface more because of the visual results in a map, which rendered it also more intuitive with respect to the Natural Language Interface.

However 5 participants, among these some who already had an experience with GIS interfaces before, instead preferred the Natural Language because of the degree of detail this provided in the results (showing links to the resources). This was conceived for a more academic type of search whereas the ArcGIS is good for having a general visualization of the results but without adding further details.

Overall the main reason of appreciation and intuitiveness was based on visual presentation of the results. The Natural Language interface does not present results in this form, as this was not the focus of our research, but this suggests a major potential area for improvement.

From the explanations that the participants gave in their answers it seems their appreciation and so their preference towards one of the two interfaces was strictly linked to their ease of use and

that their ease of use was linked to their intuitiveness (e.g., prevalence of answers of the kind 'I liked it more because it was easier to use ..' or 'I think it was more intuitive for its visual aspect').

Results : System Usability Scale

The System Usability Scale or (SUS in Appendix 4 below) was mainly focussed on the ease of use of the two systems and so satisfaction with them in terms of:

-complexity of the system
-need of technical help or additional instructions
-consistency and integration of the functions in the system

A first general psychometric analysis confirms the overall trend coming out of the open question, which means that the ArcGIS appeared easier to use in comparison to the Natural Language Query Interface (table 3, Appendix 4) (average SUS score of 66 for ArcGIS vs. 55 for the Natural Language Query Interface).

However, statistical testing revealed insufficient evidence to assume normality for the data collected (Kolmogorov-Smirnov test for normality with Lilliefors Significance Correction, see Appendix 4), meaning that the collected data did not follow a normal distribution. Therefore a two tailed Wilcoxon Signed Ranks test (a non-parametric related samples difference test) was performed to establish the level of significance of the difference between the two data sets, revealing a significant difference ($Z = 3.184$, significant at $p \leq 0.001$). This result strongly indicates that INTERFACE-B has meaningfully higher perceived usability than INTERFACE-A (see results in table 4, Appendix 4).

A brief overview to the singular questions in the SUS scale (tables 5 and 6 in Appendix 5) shows that:

1. The majority of the participants would not use the NL Interface often, but did not find it complex to use. 14 of them would need technical support, 16 would not. 34 participants think this system can be learned quickly although 20 answered that it is a bit cumbersome.

2. In comparison the ArcGIS interface was not complex, and 48 participants believed ArcGIS is easier that the NL interface even though more people would need a technical support for the ArcGIS rather than the NL. 15 people strongly agreed with the integration of the functions behind ArcGIS against the 4 of the NL interface. More people felt confident using ArcGIS more than using NL because this was not cumbersome to use.

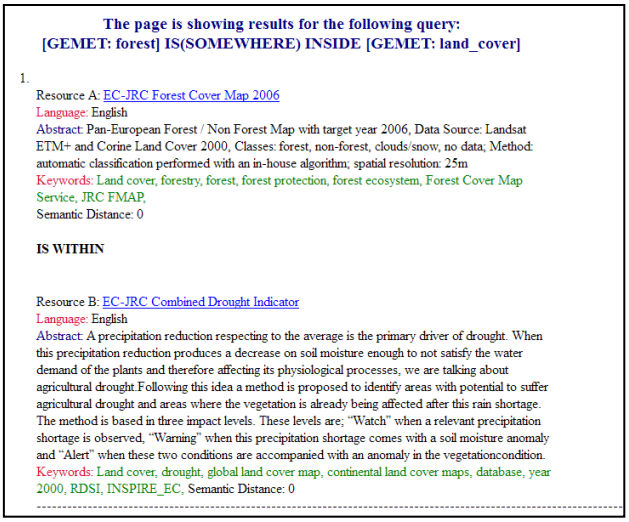
2.3 General Discussion of Results from User Study

Generally, participants to part 2 of the user study seem to think that the ArcGIS interface be more intuitive than the Natural Language one because of the language hindrance opposed to the nice visualization provided by ArcGIS. However, the experiment was conducted on non-GIS experts and they were given support (with demos and instructions), as well as confined to very specific tasks within ArcGIS, meaning they were not exposed to the overall difficulty of a more sophisticated software such as Arc. Prior to the experiment, we set up the layers that they would need, so they were simply required to open the software with the correct template loaded, select the layers and conduct the query using instructions given in the demo. In a real-life situation using ArcGIS, much effort is required to identify and select layers, and to learn how to manipulate them and use other GIS functions. The participants who were GIS experts, who have a deeper

knowledge of GIS interfaces, in part 1 of the user study revealed that ArcGIS is certainly more difficult and technical than the NL Query interface.

Obviously the Natural Language Interface has to be improved in terms of 'cosmetics' to be made more user -friendly. Specific points in this regard were:

1. Presentation of results on a map instead of a textual list (in figures 2 and 3 below)
2. Better tools for selection of NSM primitives. The table used was not user friendly.



The page is showing results for the following query:
[GEMET: forest] IS(SOMEWHERE) INSIDE [GEMET: land_cover]

1.

Resource A: EC-JRC Forest Cover Map 2006
Language: English
Abstract: Pan-European Forest / Non Forest Map with target year 2006, Data Source: Landsat ETM+ and Corine Land Cover 2000, Classes: forest, non-forest, clouds/snow, no data; Method: automatic classification performed with an in-house algorithm; spatial resolution: 25m
Keywords: Land cover, forestry, forest, forest protection, forest ecosystem, Forest Cover Map Service, JRC FMAP,
Semantic Distance: 0

IS WITHIN

Resource B: EC-JRC Combined Drought Indicator
Language: English
Abstract: A precipitation reduction respecting to the average is the primary driver of drought. When this precipitation reduction produces a decrease on soil moisture enough to not satisfy the water demand of the plants and therefore affecting its physiological processes, we are talking about agricultural drought.Following this idea a method is proposed to identify areas with potential to suffer agricultural drought and areas where the vegetation is already being affected after this rain shortage. The method is based in three impact levels. These levels are; "Watch" when a relevant precipitation shortage is observed, "Warning" when this precipitation shortage comes with a soil moisture anomaly and "Alert" when these two conditions are accompanied with an anomaly in the vegetationcondition.
Keywords: Land cover, drought, global land cover map, continental land cover maps, database, year 2000, RDSI, INSPIRE_EC, Semantic Distance: 0

Figure 2: example query results from NL query interface for forest INSIDE land cover

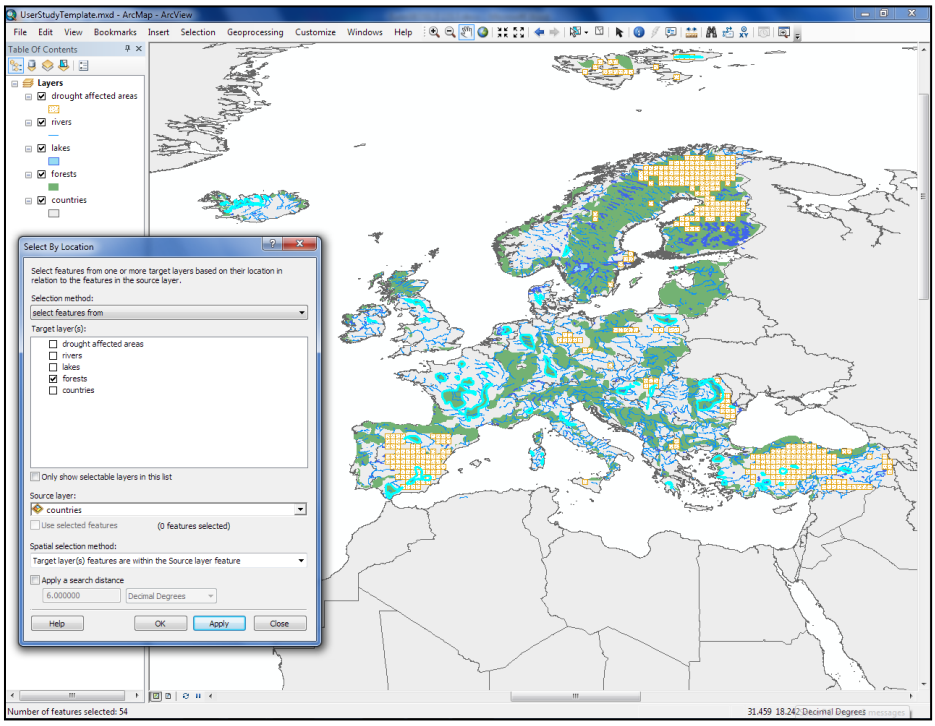


Figure 3: example query results from ArcGIS10 for forests within countries. To be underlined in light blue are the forests that are completely within European countries

We did not focus on these aspects of the interface, because they were not the focus of our research, but they did effect the evaluation (among the open questions in both parts of the user study participants clearly stated that the NSM table was too cumbersome to skim or use and the great majority of them in both parts of the user study confirmed that integrating the approach with a map showing the results would be more helpful especially for a non-expert).

A recommendation that arose from the results of this study is that the natural language querying approach might be usefully integrated with more technical GIS software, so that the visualisation capabilities of the latter are available, along with a natural language interface. However, this does not result the complexity of the GIS, and it is likely that GIS users will be sufficiently familiar with query interfaces not to need the natural language approach. In contrast, users of simple online mapping tools like Google Maps may benefit more from the integration of a natural language querying tool, particularly considering that the capabilities for spatial querying in tools of this kind are currently very limited.

3 PROGRESS AND FUTURE PLANS

In earlier reports, we discussed a three-phase approach to the completion of Task 2.5, as follows:

1. Basic search interface using ontology selection of concepts and semantic similarity matching using ontology alignments.
2. Natural language spatial query combining ontology selection with semantic similarity matching using ontology alignments, and NSM expressions of spatial queries.
3. Augmentation of natural language querying to include other aspects, possibly including temporality.

Phases 1 and 2 were complete with Deliverable 2.5.2 in June 2011. In Phase 3, we have concentrated on extending the natural language spatial query capabilities of the interface, including improving the method for selection of NSM terms (although obviously it can be improved further) and extending the Prolog knowledgebase that maps the NSM expressions to spatial queries (see deliverable 2.5.2). Also, in Phase 3 we conducted the user studies described herein.

With these activities, we believe that we have achieved what was proposed at the beginning of the project for task 2.5 of the EuroGEOSS project.

The Natural Language Query Interface is a prototype of an interface to demonstrate the application of NSM for spatial querying. We hope to develop and extend this work further in two directions:

1. The improvement of the interface and integration with existing basic GIS tools, responding to criticisms or the user interface usability and presentation.
2. The extension of research in natural language querying by the development of a more comprehensive and less restricted natural language spatial querying method, responding to difficulties found in the user studies in selecting appropriate terms and in formulating NSM queries.

4 CONCLUSIONS

This report has provided results for the user study applied to the Natural Language Query Interface. The user study was divided into two parts distinguished by the use of two different research methodologies: qualitative and quantitative. Both studies reveal that at present the NL

interface is more rigid and less preferred than a traditional GIS interface (e.g., ArcGIS10), however from both studies it emerges that the NL has linguistic advantages that could be merged to the facilities supported by GIS software making the latter more suitable for non-technical researchers.

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Appendix 1: OUTPUT AND DISSEMINATION

As concerns the outputs produced by Task 2.5, the major contributions since the beginning of the project thus far include:

1. The alignment of thesauri terms (SBA-GEMET and INSPIRE spatial Data Themes) in the EuroGEOSS infrastructure.
2. The translation of the monolingual (English only) version of the GEOSS SBAs in Italian Spanish and French to accommodate easy multilingual discovery for international users.[4]
3. The development of a demonstrator as delivered in June 2011.

Also, a number of papers for dissemination in journals and at international conferences have been and are being prepared.

Papers in preparation:

'Multilingual Knowledge Systems. The EuroGEOSS' Case Study:GEOSS' Societal Benefit Areas Translations for Italian, Spanish, French and Slovenian' addressing the issue of cross translation of thesauri.

'Determining Semantic Equivalence of Restricted Spatial Linguistic Expressions in Natural Semantic Metalanguage ' (in preparation for journal publication), this paper presents the semantic similarity matching of NSM expressions to spatial queries supported by linguistic theories.

'Multilingual Natural Language Spatial Querying using Natural Semantic Metalanguage' (in preparations for journal publication). This paper discusses in more detail the linguistic and technical details behind the approach undertaken during the implementation of the Natural language Query Interface with user evaluation results and further implementations.

Papers and projects already disseminated:

Alignment of GEMET and the GEOSS SBAs.

Translation of the SBAs into French, Spanish and Italian (web dissemination through Wikipedia).[5]

Internal report on 'Domain Ontologies to Support EuroGEOSS'. An inventory of semantic schemes out of a sample selected by experts to be inserted and aligned in the EuroGEOSS infrastructure.

Co-authored paper with Javier Nogueras (University of Zaragoza), 'WP 2 SECTION: User-Driven Requirements for Resource Annotation'. A user instruction paper for the users based on how to use the University of Zaragoza's metadata Editor, CatMDEdit, to annotate resources and the EU-JRC SKOS Matcher tool to align thesauri.

[4] Several inputs from thematic experts and professionals have been received for the improvement of both semantic mapping of the thesauri and the SBAs translations.
[5] http://en.wikipedia.org/wiki/Societal_Benefit_Areas

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Appendix 2: USER STUDY PART 1 MDT WORD CLOUD

MDT word	Recurrence	MDTWord	Recurrence
Rigid	7	Approachable	1
Simple	3	New	3
Easy-to-use	3	Stable	1
Friendly	2	credible	1
Intuitive	4	Straightforward	1
Accessible	4	Boring	1
familiar	1	Non-standard	1
Innovative	3	Fun	1
Useful	2	Awkward	1
Clear	1	Powerful	1
Ambiguous	1	System-oriented	1
Fast	2	Unpredictable	1
Simplistic	1	Intimidating	1
Frustrating	2	professional	1
Creative	2	usable	2
Understandable	3		

Table 1: recurrence of Microsoft Desirability Toolkit words

Appendix 3: USER STUDY PICTURES

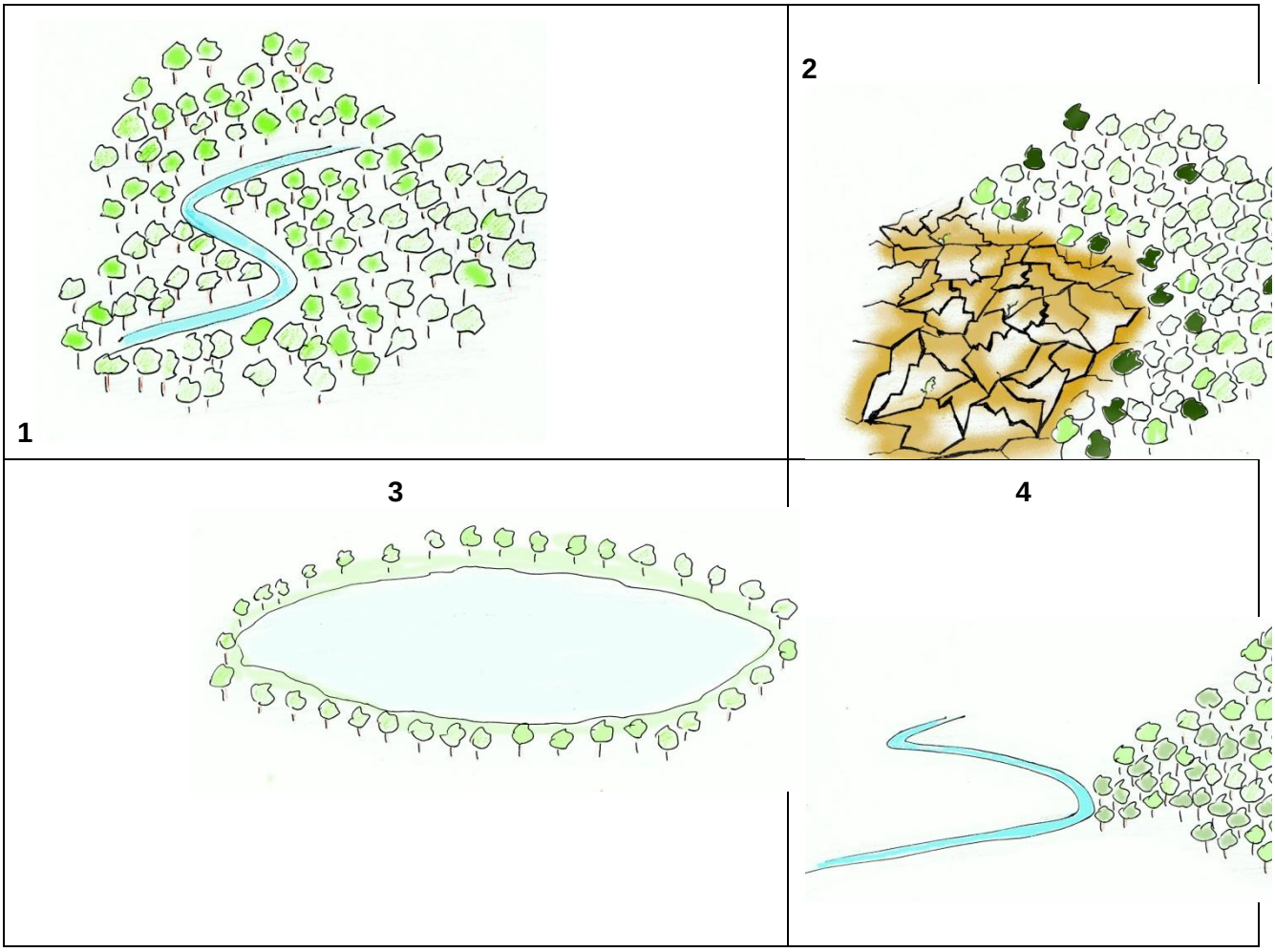

Table 2: 4 pictures used for the experiments. The all 4 were used for part 1 user study and only number 1 and 2 were used for part 2 of user study.

Appendix 4: USER STUDY PART 2 SUS SCALE

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

Appendix 5: SUS SCORE FOR PART 2 USER STUDY

NL Query Interface SUS score average	**ArcGIS 10 SUS score average**
55.38135593	66.56779661

Table 3: SUS average score each interface

		Kolmogorov-Smirnov test					Percentiles	
Interface	N	Stat.	Sig.	Median	Max.	Min.	25th	75th
NL Query Int	59	.112	.061	50.0	92.5	17.5	42.5	70.0
ArcGIS10 Int	59	.117	.042*	70.0	95.0	30.0	57.5	77.5

Table 4: Normality testing and descriptive statistics for SUS scores

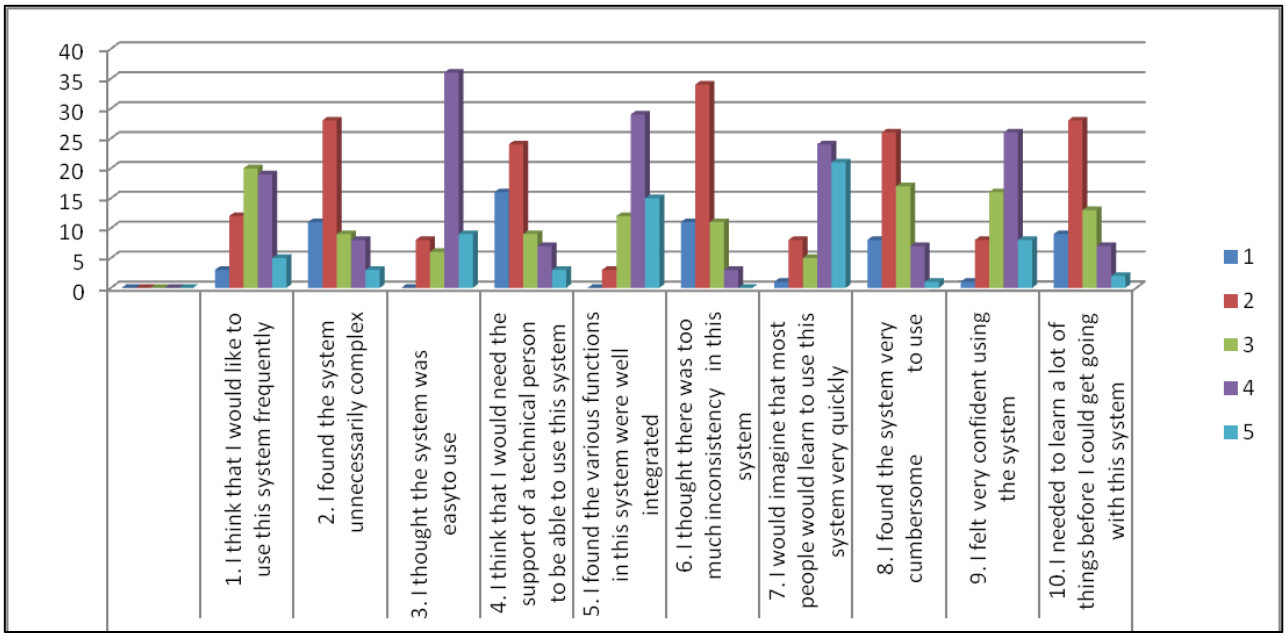

Table 5: Chart SUS each item'score for the ArcGIS Interface where 1 = strongly disagree and 5= strongly agree

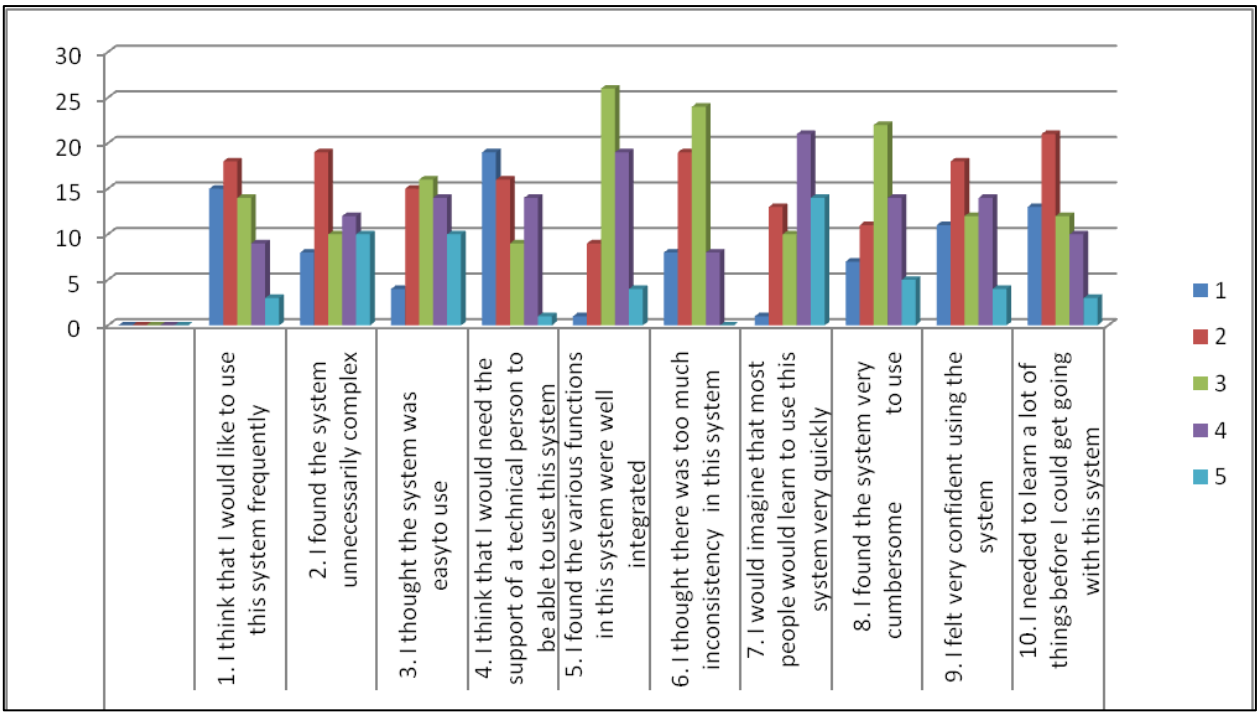

Table 6: Chart SUS each item's score for the Natural Language Query Interface where 1 = strongly disagree and 5= strongly agree