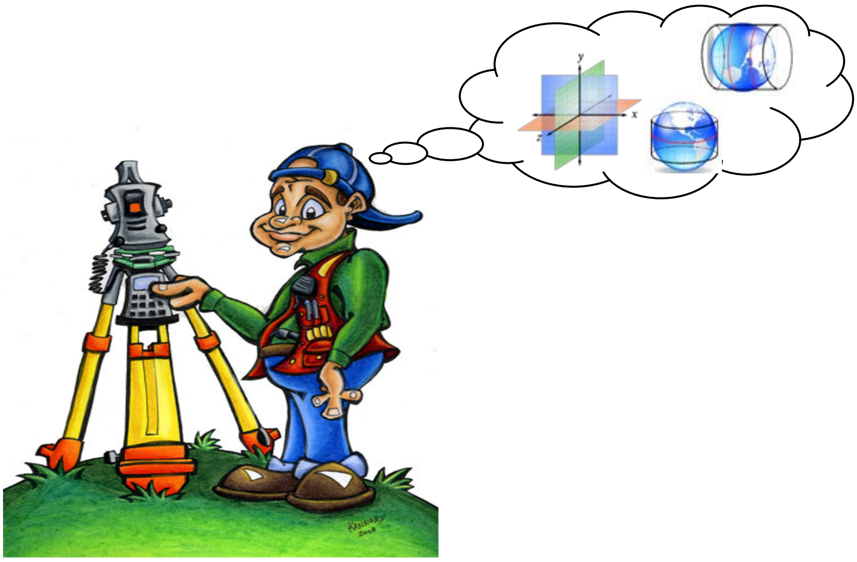
Laboratory of Geo-Information Science and Remote Sensing

Thesis Report GIRS-2015-30

Comparison of spatial thinking levels between GIS and non-GIS students in understanding geographical space

Marthalina Indhawati



August 2015

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Marthalina Indhawati

Supervisor:

dr. ir. Ron van Lammeren

A thesis submitted in partial fulfillment of the degree of Master of Science

at Wageningen University and Research Centre,

The Netherlands.

August 2015
Wageningen, The Netherlands

Thesis code number: GRS-80424
Thesis report: GIRS-2015-30
Wageningen University and Research Centre
Laboratory of Geo-Information Science and Remote Sensing

Acknowledgements

"He has made everything beautiful in its time." (Ecclesiastes 3:11)

First of all, I would like to thank to my Lord, Jesus Christ, for giving me strength and grace for every single second in my life. My deepest thanks to dr. ir. Ron van Lammeren who gave me detailed discussions, feedback, and many great ideas during my thesis. It helped me a lot to become more critical in the scientific direction. Moreover, it was a new experience for me learning about this interesting topic.

I am also grateful to Prof.dr. ir. Arnold Bregt for giving me valuable feedback during my thesis. Special thanks to my colleagues from STPN and UNS for helping me during the test and for the cooperation during my thesis. Thank you so much for all the students from MGI – Wageningen University, STPN, and UNS who had participated in my spatial thinking test. Special thanks to Marnix Van den Brande who always supported and prayed for me during this period, it meant a lot for me.

Lastly, I would like to say thank you to my beloved parents, brother, and sister who always keep praying for my health and success in my study. After finishing this thesis, I hope my sister would like to join in the geo-science field in the next step of her education.

I hope this thesis would give a contribution for the National Land Agency of the Republic of Indonesia and especially for the National Land Academy – Sekolah Tinggi Pertanahan Nasional to achieve their visions in establishing professional human resources in technical and land administration.

Abstract

National Land Academy (Sekolah Tinggi Pertanahan Nasional – STPN) is an academy under the Ministry of Land and Spatial Planning/National Land Agency. The main task of STPN is to organize an education program in land matter under the NLA authority. One of the study programs in STPN is Diploma IV, a four year study program only for the Ministry of Land and Spatial Planning/National Land Agency officers, who already work for a certain period of time. Since the National Land Agency is the only ministry that can publish land certificates, it is very important for all officers, including Diploma IV students, to understand the geographical space. Knowledge about concepts like coordinate systems, projection systems, boundaries, direction, etc., is crucial in order to avoid land disputes that might happen from the publication of land certificates. The Diploma IV students of the STPN should be familiar with spatial thinking in their study activities especially spatial thinking in the geographical space. However, there has never been applied a spatial thinking test to STPN students before. This research was the first examination of the relationship between the level of GIS learning outcomes and spatial thinking of STPN students in the geographical space. Such a spatial thinking test for the geographical space had been successfully developed by Firdiansyah (2012) and applied on students in the Netherlands. However, this test has not yet been validated to measure spatial thinking level in a larger number of participants outside the Netherlands. In this study we aimed to find the relationship between GIS learning outcomes levels and spatial thinking levels of STPN students in understanding the geographical space. Firstly, we performed a spatial thinking pre-test using the original test material developed by Firdiansyah (2012). This pre-test had been applied to students of the Master of Geo-Information Science in the Netherlands in order to get feedback and to evaluate and improve the test material. Secondly, we translated the test material into Bahasa language and performed the spatial thinking in geographical space test to 52 STPN students, consisting of 1st year and 2nd year students (GIS students) and to 43 students following the Informatics Engineering Diploma at Sebelas Maret University (non-GIS students). We calculated the mean scores of our populations based on the number of the correct answers. Our results showed that the mean score of the 2nd year students was higher than the 1st year students. Furthermore, we also compared the result of the GIS students and the non-GIS students. It showed that the GIS students had a higher score than the non-GIS students. We validated the result using the independent samples t-test with a 0.05 significance. The purpose of this validation was to analyze whether there is a statistically significant difference in the mean scores between the populations. The validation showed that there were mean score differences between the 1st and 2nd year STPN students and between GIS and non-GIS. We concluded that the more GIS learning achieved, the better spatial abilities are achieved by the students and that the STPN (GIS) students have a better understanding in spatial knowledge than the non-GIS students. Next to analyzing the difference between 1st year and 2nd year STPN and between GIS and non-GIS students, we also analyzed whether we observe a significant difference between male and female students within our subpopulations. Based on previous studies, we would expect that the spatial thinking ability of male students would be higher than for female students, this hypothesis is confirmed after analyzing our test results. However, after performing an independent samples t-test with a 0.05 significance, we observed that the difference between male and female students was for both groups not statistically significant. The results of this study give many opportunities for STPN to evaluate their curriculum and implement specific study activities. The outcome of this thesis can be used to improve the STPN curriculum, which is necessary for NLA and STPN to gain a high qualified human source in land management and land administration

Keywords: spatial thinking, geographical space, National Land Academy, Sekolah Tinggi Pertanahan Nasional, Indonesia.

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List of acronyms, special terms and abbreviations

BPN RI	: Badan Pertanahan Nasional Republik Indonesia
GIS	: Geographic Information System
MGI	: Master of Geo-Information Science
NLA	: National Land Agency
NRC	: National Research Council
SKS	: Sistem Kredit Semester
STPN	: Sekolah Tinggi Pertanahan Nasional (National Land Academy)
TM 3°	: Transverse Mercator 3°
UNS	: Universitas Negeri Sebelas Maret (Sebelas Maret University)

1. Introduction

1.1 Background information

Indonesia, as an agrarian country, considers land as a natural resource which is very valuable for the whole society. Land is a basis for the cultural and social development, and a source of prosperity. Therefore, the government puts high attention to land development and management in Indonesia (Winoto, 2009). Indonesia is an archipelago country with approximately 17,504 islands. It has a total area of 9.8 million km2, from which about 1.9 million km2 is land area (Badan Pusat Statistik - National Statistic Agency of the Republic of Indonesia, 2014). Administratively, since July 2013, Indonesia has 34 provinces, 412 districts, and 93 cities (Kementerian Dalam Negeri Republik Indonesia -Ministry of Home Affairs of the Republic of Indonesia, 2014).

From the total Indonesia land area, 70% is zoned as forest land and 30% is non-forest land which is administrated by the National Land Agency (Bell and Srinivas, 2013). Organizationally, the NLA's structure has changed multiple times since 1960 until now. In October 2014, NLA's structure had been changed from non-ministry to ministry; it is merged with another ministry called Kementerian Agraria dan Tata Ruang/Badan Pertanahan Nasional (Ministry of Land and Spatial Planning/National Land Agency). Generally, the main task of NLA is supporting the President in land administration and land management at national, regional and sectoral levels, which is about land surveying and mapping, land rights and registration, land planning, land controlling, land acquisitioning for development of public interest, and land disputes assisting. In October 2014, NLA's structure had been changed to be merged with another ministry called Kementerian Agraria dan Tata Ruang/Badan Pertanahan Nasional (Ministry of Land and Spatial Planning/National Land Agency). NLA has a vertical organizational structure (Fig. 1): central office, regional offices at province level, and local offices at district level. A vertical organizational structure means NLA has its office representation in central, province and district level. Each level has different tasks and functions with central office as the policies coordinator.

The government of the Republic of Indonesia realized that in order to have an adequate land management, it is very important to have a high qualified human source in land management. Hence, in 1993, the government of the Republic Indonesia formed the National Land Academy (Sekolah Tinggi Pertanahan Nasional – STPN) by President Decree Number 25/1993 (Keputusan Presiden Nomor 25/1993 tentang Pendirian Sekolah Tinggi Pertanahan Nasional). According to this rule, the main task of the STPN is to organize an education program in land matter/agrarian under the NLA authority.

One of the visions of the STPN is the establishment of professional human resources in technical and land administration. Those human resources are capable to follow the latest developments in science and technology in order to improve the quality of land services to the community. Furthermore, to achieve its vision, the STPN has been carrying out some missions, i.e. organize the education, research, and service. Those missions are targeted to support the development of land administration, establish an academic life by optimizing the utilization of available resources, and collect, process, analyze, and present the land/agrarian objects for development of knowledge and information.

The STPN is responsible to the Head of the NLA by the NLA Secretary. However, STPN also has its own organization, i.e. Head of STPN, STPN senate, Academic section, Administrative section, and supporting section (Fig. 1).

The head of STPN is responsible for all the studying processes within STPN. The head of STPN has a head assistant to help its tasks. Furthermore, the STPN student council is very important, since it has as their main task to formulate the academic policies and the development of STPN. The academic section has main roles in the implementation of academic, teaching and educational activities, in combination with its role to form cooperation's with other parties. The administrative section is responsible in the implementation of activities planning, financial management, and human resource activities. Meanwhile, the supporting section consists of a library, laboratory, and computer center.

STPN has two study programs: Diploma IV of land management and land mapping and Diploma I of cadastral measurement and mapping. The Diploma IV is a four year study program (four levels) only for the National Land Agency of the Republic of Indonesia (NLA) officers, who already work for a certain period of time at NLA. Meanwhile, the Diploma I is one year study program for non-NLA officers, usually intended by senior high school students. The main difference between Diploma IV programs and bachelor programs is that Diploma IV has more practical teaching activities (60%) than theory teaching activities (40%).

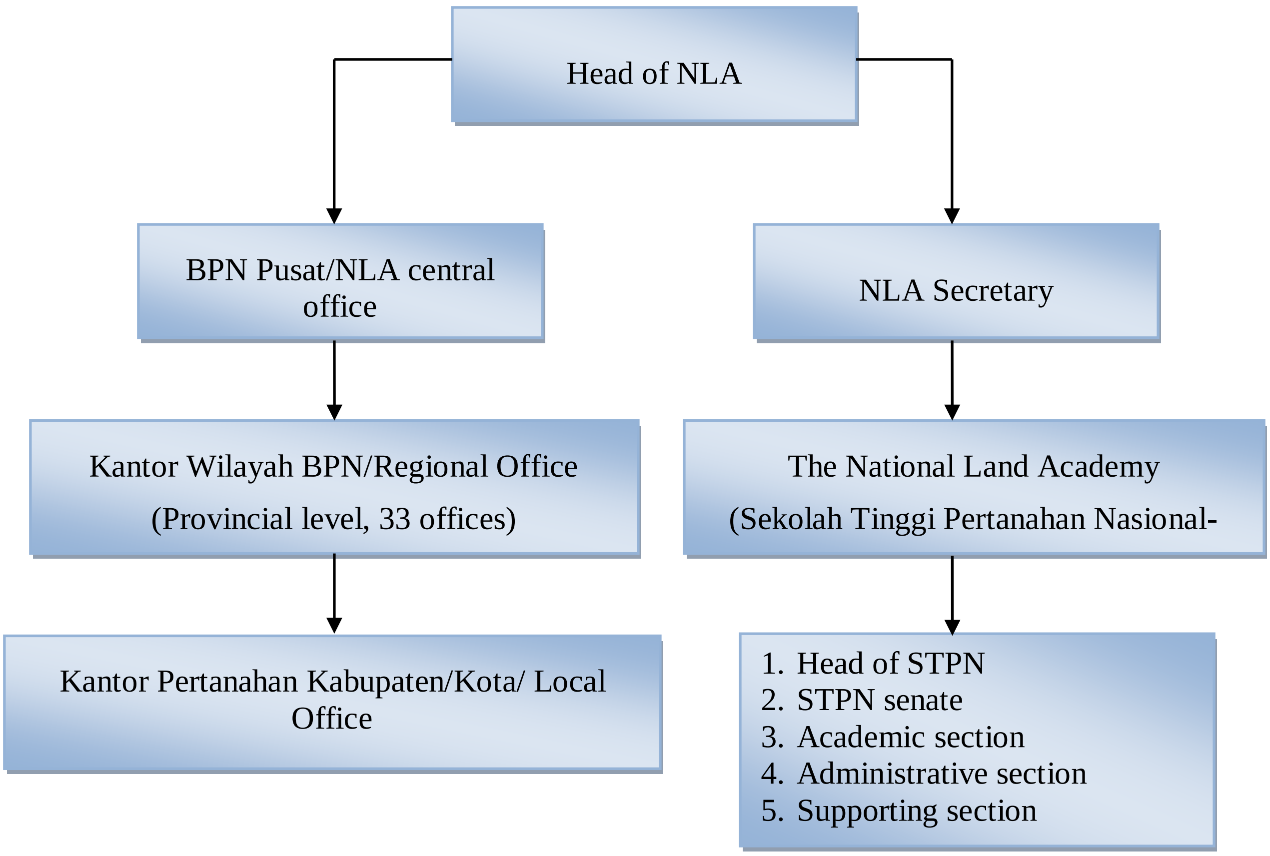

Figure 1. The organizational structure of NLA and STPN. Source: adapted from Presidential Decree Number 20/2015 and President Decree Number 25/1993.

1.2 Problem statement

One of the study programs in STPN is Diploma IV, which is at the same level with bachelor/graduate program (1st year, 2nd year, 3rd year, and 4th year students). The Diploma IV is a four year study program (four levels) only for the National Land Agency of the Republic of Indonesia (NLA) officers, who already work for a certain period of time at NLA. The curriculum for this diploma is a comprehensive curriculum related to land administration and land management. Diploma IV has both theory and practical lessons related to Geographical Information System (GIS) in their subjects, i.e. GIS, cartography, digital data processing, land information system, etc. Moreover, all STPN's students are NLA officers in which most of them deal with land certificate process and legal matters, i.e., land measurements and land mapping. Since the National Land Agency is the only ministry that can publish land certificates, it is important for all officers, including Diploma IV students, to understand the geographical space, e.g. coordinate system, projection system, boundary, direction, etc, in order to avoid land disputes that might happen from the publication of land certificates. The Diploma IV students of the STPN should be familiar with spatial thinking in their study activity especially in the geographical space since spatial thinking and learning are recognized as essential components of geography education (Verma, 2015). However, there is no test applied to STPN students regarding spatial thinking before. The students will only have an exam for every subject after six months of studying. This research was the first study between the level of GIS learning outcomes and spatial thinking in the geographical space.

Many forms of thinking exist in our lives, for instance verbal, logical, mathematical, hypothetical, statistical, etc (NRC, 2006). One comprehensive report regarding spatial thinking has been published by National Research Council in the USA (NRC) in 2006: "Learning to Think Spatially". Spatial thinking is defined as "a collection of cognitive skills comprised of knowing concepts of space, using tools of representation and reasoning processes" (NRC, 2006). Spatial thinking includes many different spaces. According to Montello (1993), the spectrum of spaces is defined into four scales, i.e. figural, vista/personal, environmental, and geographic scale. Moreover, Golledge et al. (2008a, 2008b) divided the spatial thinking level into five levels: primitive, simple, difficult, complicated, and complex. Furthermore, the NRC (2006) mentioned that GIS plays an important role in spatial thinking. GIS reflects many of the functions and operations of spatial thinking. It is stated that "GIS had a clearly demonstrated potential as a support system for spatial thinking" (NRC, 2006). Many studies have been performed by some researchers that show the capability of GIS in supporting spatial thinking. A study performed by Self et al. (1992) shows that GIS is able to develop student's spatial abilities since they have to know the concept of space, i.e. scale, projection, geometry, and topology. Furthermore, Hall-Wallace and McAuliffe (2002) state that learning with GIS improves student's spatial skills in problem solving, analysis, and spatial visualization. The study done by Hagevik (2003), shows that GIS helps middle school science students in spatial reasoning. Furthermore, Forer and Unwin (1999) stated that GIS develops map reading skills and a tool for spatial thinking and decision making.

A study performed by Lee and Bednarz (2009) has developed a spatial skill test to examine the effect of GIS learning on the spatial thinking ability of state university students. This research used a set of multiple choice questions and performance tasks to evaluate students' spatial thinking ability, including overlaying and dissolving a map, reading a topographic map, evaluating several factors to find the best location, recognizing spatially correlated phenomena, constructing isolines based on point data, and differentiating among spatial data type. Another study that developed a spatial thinking test was performed by Firdiansyah (2012). He developed a spatial thinking in geographical space test and used Geography and non-Geography students in the Netherlands in order to examine their level of spatial thinking. The test had four different parts referred to the spatial thinking level by NRC (2006) and Golledge et al. (2008a, 2008b), i.e. primitive, simple, difficult/complicated, and complex. That research only used 35 (thirty five) participants in total and its result showed that the higher spatial thinking level gave lower score, which means the spatial thinking test was good developed by Firdiansyah (2012). However, this test has not yet been validated to measure spatial thinking level in a larger number of participants outside the Netherlands. Therefore, in this thesis we evaluated and applied the test developed by Firdiansyah (2012) using comparable participants, i.e. Geography (GIS) and non-Geography (non-GIS) students with larger participants, in total 100 (a hundred) participants.

1.3 Research objectives and research questions

The overall objective of this thesis is to find the relationship between GIS learning outcomes levels and spatial thinking levels of National Land Academy (Sekolah Tinggi Pertanahan Nasional-STPN) students in understanding geographical space.

This thesis will aim to answer these following questions:

- Can the test developed by Firdiansyah (2012) used for finding the relationship?
- What relationship does exist between GIS learning levels (outcomes) and spatial thinking levels of STPN students?
- Do spatial thinking levels of STPN (GIS) students differ from non-GIS students?
- Will female students perform different than male students considering spatial thinking?

1.4 Overview of report

This thesis evaluates and investigates the developed spatial thinking in geographical space test to find the relationship between GIS learning level and spatial thinking levels of National Land Academy (Sekolah Tinggi Pertanahan Nasional-STPN) students in understanding geographical space.

Chapter one provides the problems and issues related to the National Land Academy (Sekolah Tinggi Pertanahan Nasional-STPN) in Indonesia. Moreover, it provides the research objectives, research questions, and an overview of report.

Chapter two includes the theoretical background and literature review for this thesis. We describe the geographical space, the level of spatial thinking, taxonomy of educational objectives in cognitive domain, and GIS learning in the Sekolah Tinggi Pertanahan Nasional-STPN.

Chapter three gives an overview of the methodology used in this thesis. It briefly describes the study population, the data sets, and methodology used. It provides a flowchart of the whole process, which includes all steps, from the data obtained until the final result. For every process a description is given which includes both the data and methods used to answer all the research questions.

Chapter four presents the main results obtained for answering the research questions. It presents the results of observing the pre-test of spatial thinking test material and the results of spatial thinking in geographical space test for both 1st year and 2nd year STPN students. Moreover, we also observe the test result between the GIS and non-GIS students and the test result based on the gender in the 1st year and non-GIS students group.

Chapter five discusses the insights gathered from the main results in this thesis. Moreover, it also compares the main results with the other studies.

Chapter six summarizes the main conclusions obtained regarding to the objectives. Moreover, it includes some recommendations and possible suggestions to be investigated in future research.

2. Theoretical background

2.1 Geographical space

People's activities cannot be separated from spaces; it always involves spaces, i.e. we are thinking, making decisions, and behaving in space (Lobben and Lawrence, 2014). The same is true for spatial thinking; it needs spaces which are continuously developing for many years in many domains (Golledge et al., 2008a; Golledge et al., 2008b; Hegarty et al., 2010). Therefore spatial thinking can be considered as the concept which is about where things are and where they happen in space and time and especially about where they are in relation to others (Logan, 2012). In this subchapter we will focus on the geographical space description from several studies.

Beguin and Thisse (1979) stated that "geographical space is a major concept in spatial analysis". Geographical space is not only about length-distance, relative position or areas, it is a space that consists of a collection of places, a vector of attributes, and single or several distances on the collection of places (Beguin and Thisse, 1979). In addition to this, a paper by Dusek and Szalkai (2008) considered geographical space as continuous, in which each point of a topographical map can be interpreted as an element of space. Another description of geographical space is given by Montello (1993). The determination of the sense of spaces was based on the projective size of spaces compared to a person's body. Montello (1993) specifically mentioned that spatial thinking includes many different spaces, it is defined into four scales, i.e. figural, vista/personal, environmental, and geographic scale. Geographical space is considered as the space that is bigger than the human body which should be understood and learned using symbolic representations, e.g. maps and models. This definition is in line with Downs and Stea (1973) who also considered geographical space as a concept having a large size to be understood and learned at one time. The smaller representations, maps and models, would reduce the spaces into a smaller size than the human body. Hence, it will be easier for people to understand and learn their surroundings. Moreover, Montello (1993) mentioned that states and countries are good examples of geographical spaces because the size of both should be reduced into maps or models to be learned and visualized easily. The author also stated that people who study and explore geography science are the most common who use the geographical spaces. In accordance with Montello (1993), Mark et al. (1999) also described that the geographical spaces has a large size and should be transformed into smaller maps or models to be explored.

2.2 Spatial thinking levels

In order to understand the different spatial thinking levels we will first start with defining the concept of spatial thinking. In the research communities there is no clear consensus about a definition of spatial thinking (Madsen and Rump, 2012). For the purpose of this study we will follow the definition given by the report of the National Research Council (NRC 2006) in which spatial thinking is defined as "a cognitive skill that can be used in everyday life, the workplace, and science to structure problems, find answers, and express solutions using the properties of space. It can be learned and taught formally to students using appropriately designed tools, technologies, and curricula". The authors of this report defined that there are three types of spatial thinking: thinking in space, thinking about space and thinking with space. Madsen and Rump (2012) elaborated further on those three types of spatial thinking. In which thinking in space is defined as the concept used to perform actions. It requires thinking in a real-world context, such as taking the bus to university and taking the shortest way from A to B. On the other hand thinking about space is more focused about the ways in which the 'world' works. It includes a scientific understanding of a certain phenomenon; for example understanding the structure of the Earth or understanding the floating pattern of a fluid. Thinking with space is the most abstract form of spatial thinking. This concepts deal with data relationships and the conversions from objects into locations. Furthermore it includes arrangements of objects in space; an example of thinking with space is a population pyramid. The three types of spatial thinking mentioned above are highly correlated.

Many researchers investigate and study about spatial thinking concepts because it is a universal concept and plays an important role in geography and geosciences. Moreover, the spatial thinking is expanding in many life aspects (NRC, 2006; Golledge et al., 2008a). Meanwhile, several researchers develop the spatial thinking levels, e.g. Golledge et al. (2008a, 2008b), Jo (2007), and Jo and Bednarz (2009). In this subchapter we will focus on the description of the different spatial thinking levels by NRC (2006) and Golledge et al. (2008a, 2008b).

NRC (2006) divided spatial thinking into four competencies that allows people to understand four ideas. First, people should start with the primitives set to conceive their surroundings. "The set of *primitives* is a way of capturing our encounters with a world full of objects (occurrences of phenomena)" (NRC, 2006). This competency includes the ability to reason and think about the object's identity, location in space, magnitude, and temporal specificity and duration. For instance, in the case of geographic location, identification needs a coordinate system or street names and numbers. Second, people should be able to add the languages of space which means they have to be able to capture the fundamental properties of objects. The languages of space consists of: 1) the language that is based on dimensionality and uses geometric (and graphic) dimensional series, 2) the language which is based on scale and uses scalar relations between objects, and 3) other languages of space that deal with frames of reference and directions. The third competency is the spatial concepts derived from the set of primitives. For instance, in a 2-D representation, people can derive distance, angle, and direction (relative to a given frame of reference). Furthermore, sequence and order, connection and linkage, boundaries, density, dispersion, shape, pattern, and region are connected to 2-D representations. In 3-D representations, people are able to derive the properties of slope or gradient, peaks, and valleys. Lastly, as the fourth competency, which is considered as the vital one, people should be able to perform operations that are derived from the space they have created. Moreover, they should also be able to interpret the relations among objects in the set. For instance, translating or rotating sets of objects with changing spatial scale.

Golledge et al. (2008a, 2008b) constructed the levels of geospatial concepts. They performed a research involving participants from grades 3, 6, 9-12, and students from a university in the United States of America. They developed the spatial thinking levels based on the geospatial concepts and generated a task ontology based on those levels. The writers recognized five levels, ranging from: 1) primitive, 2) simple, 3) difficult, 4) complicated, to 5) complex (Table 1). The requirements needed by an individual to accomplish each level are described below.

Table 1. Five levels of geospatial concepts. Source: adapted from Golledge et al. (p. 91-92, 2008a).

Levels and concepts				
Primitive (1)	**Simple (2)**	**Difficult (3)**	**Complicated (4)**	**Complex (5)**
Identity	Arrangements	Adjacency	Buffer	Areal association
Location	Distribution	Angle	Connectivity	Interpolations
Magnitude	Line	Classification	Gradient	Map projection
Space-time	Shape	Coordinate	Profile	Subjective space
	Boundary distance	Grid pattern	Representation	Virtual reality
	Reference frame	Polygon	Scale	
	Sequence			

Firstly, the primitive level is considered as the first level consisting of four geospatial concepts: identity, location, magnitude, and space-time (Table 1). At this level, the identity concept means that an individual should be able to identify objects by type or category. For the location concept, it is expected that an individual has the ability to describe a certain location using spatial terms, e.g. near, far, close, next to, etc. Furthermore, for the concept of magnitude, an individual should be able to differentiate the feature (point, line, and area) size. Whereas for the space-time concept, an individual is expected to master the change and movement of people, features, or events in space as a result of time (Golledge et al., 2008a; Golledge et al., 2008b).

Secondly, the simple level is considered as the level which is directly derived from the primitive level, e.g. the concept of arrangement could be derived from the concept of two or more locations and from the magnitude concept comes the concept of boundary distance (Golledge et al., 2008b). In general, for this level of spatial thinking, an individual is expected to identify the pattern between the origin and destination, to specify the spatial boundary and to figure out and be aware of the structures in both space and time (Golledge et al., 2008a).

Thirdly, the level considered as difficult, this level expands the previous levels. An individual should accomplish the required tasks to be in this level: understanding the nearest neighbor in a distribution, expanding the meaning of a location's direction, understanding the unique position in space, specifying an area with irregular boundaries, estimating the amount of spaces, recognizing spatial grouping, and recognizing the distribution settings (Golledge et al., 2008a; Golledge et al., 2008b).

The fourth level is the complicated level. This level requires an understanding about: area around the knot, completing the linkages between points, measuring slope between areas with different elevations, understanding the change that affects the world surface ratio, and recognizing a flow network (Golledge et al., 2008a; Golledge et al., 2008b).

Lastly, the complex level as the fifth level of the spatial thinking levels, this level relates of several concepts from previous levels. It is "involving identifying, comprehending, manipulating, and using concepts resulting from multiple combinations of previous levels and consists of abstract concepts that are needed in many facets of geospatial thinking and reasoning" (Golledge et al., 2008b). At this complex level, an individual should understand about: quantifying the similarities between the distribution of the features (point, line, area), determining a certain value based on the others value distributions, bringing the curved surface into flat papers, identifying the common spaces in the memory and conceiving the real or imagined surroundings (Golledge et al., 2008a).

2.3 Learning outcome levels in the cognitive domain

Many educational program directors are facing problems when determining educational objectives. One effort to overcome this issue is by defining the taxonomy of educational objectives (Krathwohl, 2002). According to Krathwohl (2002), "the taxonomy of educational objectives is a framework for classifying statements of what we expect or intend students to learn as a result of instruction". The framework aims to establish a similar educational objectives assessment at various universities (Krathwohl, 2002). In 1956, a handbook called *Taxonomy of Educational Objectives: The Classification of Educational Goals. Handbook I: Cognitive Domain* was published, known as the Bloom's taxonomy. This taxonomy provided the definitions of the six major levels in the cognitive domain. This taxonomy was considered not only as a measurement tool, but also as: 1) a common language for learning objectives, 2) basis for determining a particular curriculum, 3) means for determining the congruence of educational objectives, activities, and assessments in a unit, course, or curriculum, and 4) separator between the wide educational possibilities and the limited several educational curriculum (Krathwohl, 2002). Table 2 shows the Bloom's taxonomy with its description. Further on in this thesis we will discuss how these levels of the cognitive domain fit in the STPN curriculum.

Table 2. The Bloom's taxonomy in cognitive domain. Source: adapted from Huit (2011) in http://www.edpsycinteractive.org/topics/cognition/bloom.html and Teaching Effectiveness Program (TEP) in http://tep.uoregon.edu/resources/assessment.

Level	Definition	Learning objectives	Sample question verbs
Knowledge	• Recalling memorized information. • Student recalls or recognizes information, ideas, and principles in the approximate form in which they were learned. • Represents the lowest level of learning outcomes in the cognitive domain.	Know common terms, know specific facts, know methods and procedures, know basic concepts, know principles.	Write, list, label, name, state, define, identify (who, when, where, what).
Comprehension	• The ability to grasp the meaning of material. Translating material from one form to another (words to numbers), interpreting material (explaining or summarizing), estimating future trends (predicting consequences or effects). Goes one step beyond the simple remembering of material.	Understand facts and principles, interpret verbal material, interpret charts and graphs, translate verbal material to mathematical formulae, estimate the future consequences implied in data, justify methods and procedures.	Explain, summarize, paraphrase, describe, illustrate, predict, interpret, infer, convert, translate, give example, and account for.

Table 2. (Continued)

Level	Definition	Learning objectives	Sample question verbs
	• Represent the lowest level of understanding.		
Application	• The ability to use learned material in new and concrete situations. Applying rules, methods, concepts, principles, laws, and theories. • Student selects, transfers, and uses data and principles to complete a problem or task with a minimum of direction. • Learning outcomes in this area require a higher level of understanding than those under comprehension	Apply concepts and principles to new situations, apply laws and theories to practical situations, solve mathematical problems, construct graphs and charts, and demonstrate the correct usage of a method or procedure.	Use, compute, solve, demonstrate, apply, construct, how could *x* be used to *y*?, how would you show, make use of, modify,
Analysis	• The ability to break down material into its component parts. Identifying parts, analysis of relationships between parts, recognition of the organizational principles involved. • Student distinguishes, classifies, and relates the assumptions, hypotheses, evidence, or structure of a statement or question. • Learning outcomes here represent a higher intellectual level than comprehension and application because they require an understanding of both the content and the structural form of the material.	Recognize unstated assumptions, recognizes logical fallacies in reasoning, distinguish between facts and inferences, evaluate the relevancy of data, analyze the organizational structure of a work (art, music, writing).	Analyze, categorize, compare, contrast separate, differentiate, compare, distinguish x from y, how does x affect or relate to y?
Synthesis	• The ability to put parts together to form a new whole. This may involve the production of a unique communication (theme or speech), a plan of operations (research proposal), or a set of abstract relations (scheme for classifying information). • Student originates,	Write a well organized paper, give a well organized speech, write a creative short story (or poem or music), propose a plan for an experiment, integrate learning from different areas into a plan for solving a problem, formulate a new scheme for	Create, design, hypothesize, invent, develop, construct, develop, formulate, imagine, change, write a short story and label the following elements.

Table 2. (Continued)

Level	Definition	Learning objectives	Sample question verbs
	integrates, and combines ideas into a product, plan or proposal that is new to him or her. • Learning outcomes in this area stress creative behaviors, with major emphasis on the formulation of new patterns or structure.	classifying objects (or events, or ideas).	
Evaluation	• The ability to judge the value of material (statement, novel, poem, research report) for a given purpose. The judgments are to be based on definite criteria, which may be internal (organization) or external (relevance to the purpose). The student may determine the criteria or be given them. • Student appraises, assesses, or critiques on a basis of specific standards and criteria. • Learning outcomes in this area are highest in the cognitive hierarchy because they contain elements of all the other categories, plus conscious value judgments based on clearly defined criteria.	Judge the logical consistency of written material, judge the adequacy with which conclusions are supported by data, judge the value of a work (art, music, writing) by the use of internal criteria, judge the value of a work (art, music, writing) by use of external standards of excellence.	Judge, recommend, critique, justify, appraise, evaluate, which option would be better/preferable.

2.4 GIS learning in the STPN

Nowadays, STPN uses a curriculum based on the Decree of Head of STPN Number 119/KEP-800.36/VIII/2014 about the Curriculum of Diploma IV of the STPN. It regulates the subjects and courses of the Diploma IV students in the semester system. The main cores in this curriculum are land administration and land management. Several technical courses related to geographical matters are chosen to support those main cores, i.e. GIS, cartography, and remote sensing in which all students who follow these courses will have both theory and practical classes.

Based on the design of semester learning published by the STPN, they use the SKS (Sistem Kredit Semester) system in their study activities. One SKS refers to an hour of study activity. On average, for one course, the distribution between lectures and practical's is one SKS lectures and two SKS of practicals in a week. Overall, there are 24 SKS (24 hours) of lectures and 48 SKS (48 hours) of practical for one course in one semester period.

Focusing on the courses related to GIS learning level, in the first year of the study time, the students will have: a digital data processing and a cartography course. In the digital data processing, the students will have one SKS for lectures and two SKS for practicals per week. In total, it will be 24 hours for lectures and 48 hours for practicals in one semester. The learning outcome of the digital data processing course is that the students are expected to be able to create a map of the field using AutoCad. Furthermore the students should be able to create thematic maps using ArcView after following this course. This course discusses the definition and scope of digital data processing, analyzing data and performs the coordinate data calculations using Ms.Excel. Furthermore, they are expected to be able to build a textual database using Ms.Access, the creation of a spatial database using the AutoCad software, connect the spatial and textual data bases, as well as digital map creation using the ArcView software. From its study activities and especially when the students process the data some of the geospatial concepts which represents the spatial thinking levels will be touched upon, e.g. when understanding the coordinate data. In this course the students are learning some of the primitive level concepts like object's identity and location. Meanwhile, in the cartography course, the students will have one SKS of lecture and two SKS of practical per week. In total, it will be 24 hours of lectures and 48 hours of practicals in one semester. The learning outcome of the cartography course is that the students are expected to be able to understand the cartography as a science and the students should obtain skills in map making, both manually and digitally. The lecture is started with understanding the basic concept of cartography continued with map projections, reference systems, and coordinate system. Furthermore the concepts of data type, source data and data collection techniques, map characteristics, map data representations and design will be discussed. The students will also learn the applications of cartography in the field of land matters using ArcGIS software. The geospatial concepts which represents the spatial thinking level are also included in this course, e.g. object's identity by its coordinate system and location, the magnitude concept in which the students will differentiate the features (point, line, area) in the map's legend. Both concepts represent the primitive level. The students will also learn and apply a higher spatial thinking level when they learn to make maps, e.g. line, shape, polygon, coordinate system, scale, and map projection.

In the second year, the students will have more courses related to GIS learning, i.e. remote sensing, GIS, and cadastral measurement and mapping. The major learning outcome of the remote sensing course is that the students are expected to be able to understand the concept of remote sensing and its application in land matters. The remote sensing course will teach the students how to understand any information related to remotely sensed data and how to obtain the information from these data. In one semester, the students will have 24 hours of lectures and 48 hours of practical using the ER Mapper software. In this course, the geospatial concept that will be learned the most by the students is area association. It is because the students will learn how to interpret satellite images. Moreover, several concepts are implemented like: classification, shape, coordinate, object's identity, etc. Furthermore, the students will have a GIS course in their second year. The learning outcome of the GIS course is that the students are expected to be able to explain the concept of Geographic Information Systems (GIS) and its application in the field of land matters. This course will teach the students the definition and the scope of data and information, the definition of a database, the GIS components, and the GIS sub-system. The students will also learn about data types, data structures, overlay, data quality, data management, and data relationships. In the GIS course, the geospatial concepts are the most used by the students. The study activities in understanding GIS and its applications lead them to study several geospatial concepts like: object's identity, location, line, shape, classification, coordinate, polygon, buffer, profile, scale, interpolations, map projection, etc. Cadastral measurement and mapping is the third course related to the GIS learning in the second year. The learning outcome of the cadastral measurement and mapping course is that the students are expected to be able to understand and apply the techniques and procedures of the cadastral measurement and mapping. In this course, the students will learn about coordinate systems, the measurement of areas, area calculations, the making of the base map of land register, the making of registration maps, the making of graphical index maps, and how to measure and map land parcels. This course involves field study activities using measurement equipments. The distribution between theory and practical is again the same, 24 SKS and 48 SKS respectively in one semester. The interesting about cadastral in Indonesia is that the NLA uses a Transverse Mercator 3° in cadastral measurement and mapping. It is because the NLA needs a big scale to map detailed land parcels. Hence, in this course, the students will concern about transforming the field measurements into cadastral maps using this map projection. Moreover, cadastral measurement and mapping will concern about the unique location and exact boundaries. Therefore in this course will make full fill the concepts of location, boundary distance, coordinate, polygon, and scale.

In the third year, there is a photogrammetry course. The learning outcome of this course is that the students are expected to able to understand the concept of photogrammetry and its application in land matters. This course learns about the definition, the development, and the scope of photogrammetry in the cadastral field. The students will also learn about the classification of aerial photography, the geometry of aerial photography. Moreover they will be instructed to obtain knowledge about stereoscopic observations, in which they will learn about acquiring 3-D objects from aerial photography. Moreover, there will be lectures about deriving maps from aerial images using photogrammetric mapping procedures and the application of photogrammetry mapping in the field of cadastral services. Different with the other courses mentioned before, the amount of hours for theory and practical are the same, 24 hours each in total for one semester. Based on its study activities, especially deriving maps from aerial images, this course will enable students to achieve the spatial thinking concepts of object's identity, location, and area association.

Finally, in the fourth year, there is a Land Information System course. The learning outcome of this course is that the students are expected to be able to explain the meaning, the theory, and the concept of Land Information Systems. Moreover the students should be able to establish a Land Information System themselves. This course learns the scope of the Land Information System which includes the definition and the scope of Land Information Systems, the elements of Land Information and the development of Land Information Systems. The students will also learn how to present a Land Information System and how to use it as a decision support tool in land matters. The students will learn how to build a system that connects the land parcels map with the official owner together with any related information about the land parcels. In general, the spatial thinking level complex will be more studied in this course, since the students will combine several datasets, maps, and/or other information sources to make a decision in land matter. This course has 24 hours of theory and 24 hours of practicals in one semester.

Overall, the curriculum of STPN especially in the courses related to GIS learning supports the learning outcomes of the spatial thinking. Almost all the geospatial concepts which represent the spatial thinking levels are included in these courses.

3. Materials and Methods

3.1 Study population

Students we selected for this study do follow their graduate training at two provinces in Indonesia: Yogyakarta- Yogyakarta Province and Surakarta- Central Java Province - Indonesia (Fig. 2). The geographical coordinates of the study areas are between 07°33’00” S - 08°12’00” S and 110°00’00” E - 110°50’00” E. The total area of Yogyakarta Province is 3185.8 km^2 (Dephut, 2014) and the total area of Surakarta is 44.06 km^2 (Pemkot Solo, 2015).

Figure 2. Study area of spatial thinking test (red) in Yogyakarta and Surakarta, Yogyakarta -Central Java Province – Indonesia.

In this study, there were 52 STPN students in total from STPN Yogyakarta (Table 3). It consisted of 1st and 2nd year students. Every year has around 80 students in total, for this thesis we sampled 40 1st year students and 12 2nd students respectively (Table 3). The number of 2nd year participants was not adequate because in that period, the students had an activity outside the campus. We were not able to sample the 3rd and 4th year students, because they had field measurement and were on internship at NLA local offices all over Indonesia. Meanwhile, our non-GIS student's participants were 43 students (Table 3) from Universitas Negeri Sebelas Maret (Sebelas Maret University/UNS) - Informatics Engineering Diploma, in which we did not make any different level based on the student's year grade. We assumed that without GIS learning in their curriculum, no differences will be observed in spatial thinking learning levels and therefore we also did not expect differences in the results of the spatial thinking test in geographical space. Thus, we did not make any level differences for the non-GIS students.

Table 3. The number of GIS and non-GIS students in spatial thinking test in geographical space.

Gender	GIS students		Non-GIS students
	1st year	2nd year	
Male	23	12	25
Female	17	-	18
Total	**40**	**12**	**43**

3.2 Materials

3.2.1 Spatial thinking test material

In this study, we used the spatial thinking test material developed by Firdiansyah (2012). We chose to use this spatial thinking test because he developed and applied this spatial thinking test material in geographical space successfully to 35 university students in the Netherlands. Moreover, we could get the complete version of the test material. The basis of the test is the four spatial thinking concepts established by NRC (2006) as described in section 2.2. The spatial thinking test material by Firdiansyah (2012) had four different parts as the representation of four spatial thinking levels, i.e. primitive, simple, difficult/complicated, and complex. Each part of the test represented some spatial concepts to measure the spatial thinking level (Table 4). These spatial concepts are also coherent with Golledge et al. (2008a) as shown in Table 1.

Table 4. General overview of spatial thinking levels and concepts used by Firdiansyah (2012). Source: Firdiansyah (2012).

Primitive	Simple	Difficult/complicated	Complex
Identity (map primitives)	Class/group	Coordinate	Spatial reasoning
Magnitude	Boundary	Direction (orientation)	Map projection
Location	Scale	Angle	Overlay
Spatio-temporal		Profile	Spatial association
		Representation	

The test material consisted of four sessions: part A, B, C, and D (Table 5). The content and the description are shown in Appendix I. The sequence of the parts did not show the sequence of spatial thinking levels from primitive to complex level. The sequence was made randomly (Table 5). Every session had 10 (ten) questions, so overall there were 40 (forty) questions.

Table 5. The order of each part of spatial thinking test against spatial thinking levels used by Firdiansyah (2012). Source: Firdiansyah (2012).

Sessions of the test	Spatial thinking levels tested
Part A	Complex
Part B	Primitive
Part C	Difficult/complicated
Part D	Simple

3.3 Methodology

This part describes the data processing and analysis to answer all research questions. The flow chart (Fig. 3) shows the steps from spatial thinking pre-test in the Netherlands to the spatial thinking test in the two cities in Indonesia. By these procedures, we have answered the relationship between GIS learning level and spatial thinking levels of National Land Academy (Sekolah Tinggi Pertanahan Nasional-STPN) students in understanding the geographical space.

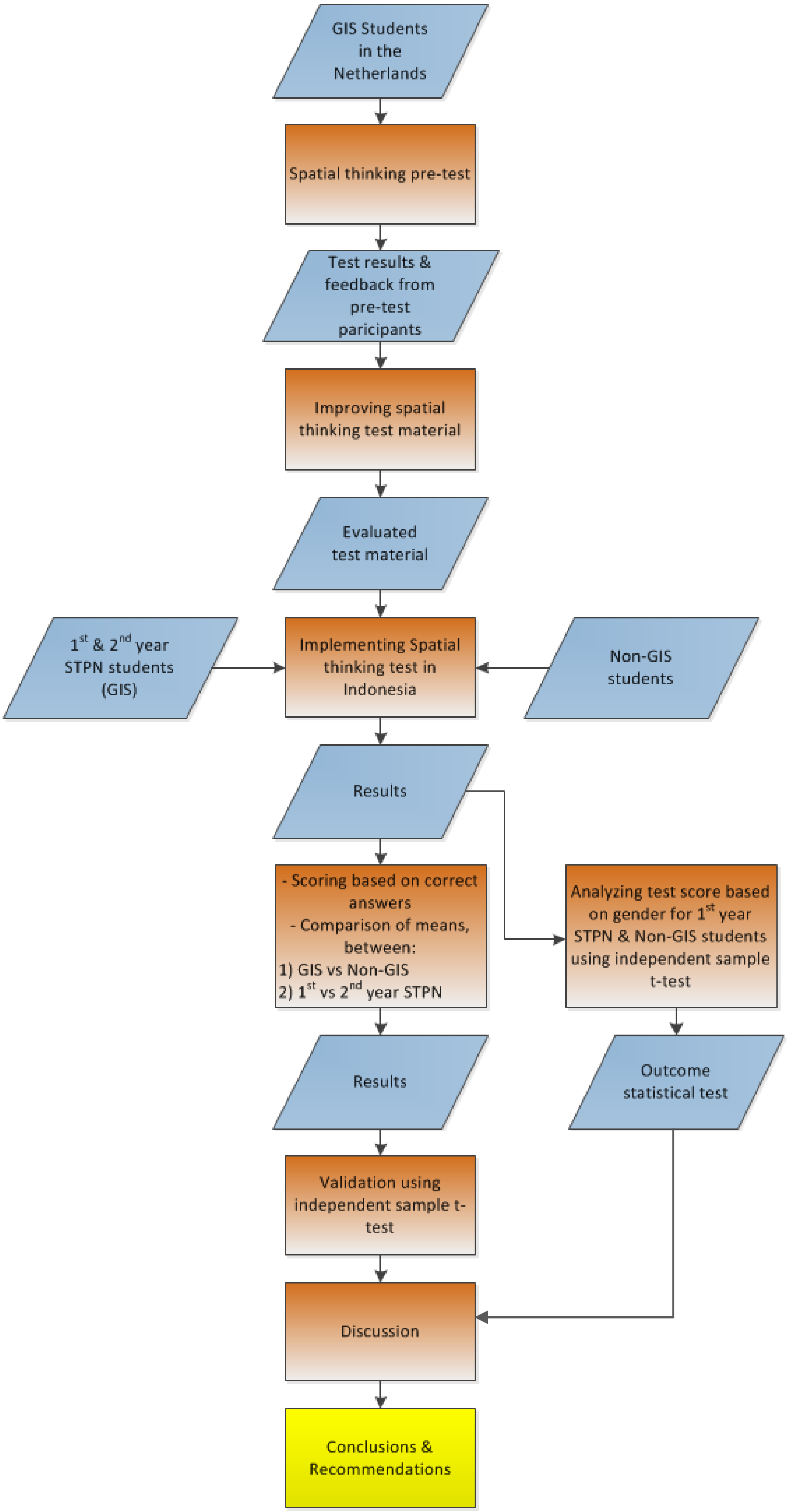

Figure 3. The steps of comparison of spatial thinking levels between GIS and non GIS students in understanding geographical space.

3.3.1 Pre-test of spatial thinking test material

We conducted a pre-test of the spatial thinking test material to five students from the Wageningen University - the Netherlands. We used the same test material developed by Firdiansyah (2012) for the spatial thinking pre-test conducted in the Netherlands. The main purpose of the pre-test was to review the original test material and improve when necessary, i.e. question's clearness (Appendix II). We chose second year students of the Master program Geo-information science in which four of them are still doing their thesis and one of them has already finished her thesis and is now doing her internship. We chose the second year students because we considered that they already have enough knowledge about GIS and spatial thinking in particular. Furthermore, some of them are active in the student activity related to newsletter and some of them have a personal website. Thus, we expected that they would be more critical in giving feedback related to spatial thinking test material. We asked them to answer the test and gave them an opportunity to give comment for each question (Appendix II) and the test in overall. We did not limit the time because we wanted them to put attention in every question and asses the question clearness. However, we asked the five participants to calculate the time they need to finish the test.

3.3.2 Pre-test result analysis and evaluation

After the pre-test of the spatial thinking test material, we examined the results, in which we analyzed both the score and the participant's feedback. Firstly, we reviewed the feedback for every question from the pre-test participants. We combined the feedback from the pre-test participants with the previous feedback from the participants in the study of Firdiansyah (2012). Furthermore we added our own evaluation to improve the spatial thinking test material, e.g. we improved the test material layout especially to make the pictures larger and more easily to read. Moreover, we added some legends to some unclear pictures, and we reduced the length of the questions, especially for the questions where we found long descriptions and long sentences. Secondly, we calculated the total mean score of the pre-test and the mean score of each part of the test. Besides to know the final score of each participant, we also examined whether the mean score of each part had the same rank/pattern with previous test by Firdiansyah (2012) in which higher level of spatial thinking resulted in a lower score.

After all improvements, we translated the test material into the Indonesia language (Bahasa), because our participants were not the students in the international class that use English as their main language in the study activities. In order to control our translation, one week before the test in Indonesia, we discussed the original and the translated test material with one teacher in STPN who teaches the GIS course and graduated from the Master of Geo-Information Science and Earth Observation at the University of Twente in the Netherlands. With this discussion, we expected that the content of the translated test was still the same with the original one.

3.3.3 Spatial thinking test using evaluated materials for GIS and non-GIS students

We performed the spatial thinking test using the evaluated materials based on the pre-test in the Netherlands to GIS and non-GIS students as our participants. In this research, we followed Lee and Bednarz (2009) in determining the term of GIS and non-GIS students. The GIS students are those who study subjects, which are related to GIS, i.e. Introduction

Figure 4. The implementation of spatial thinking test in Sebelas Maret University (left) and in STPN (right).

to GIS, cartography, and some subjects which use GIS software, i.e. ArcView, ArcGIS, Autocad, Erdas. Meanwhile, the non-GIS students are those who are not taught with subjects related to GIS. Our GIS student participants were the students of the STPN Yogyakarta and the non-GIS student's participants were Informatics Engineering Diploma students from a state university in Surakarta-Central Java.

Many studies used different number of participants for performing a spatial thinking test. Lee and Bednarz (2009) used a total of 80 respondents, consisting of 45 GIS users and 35 non-GIS user. Firdiansyah (2012) used in total 35 respondents consisting of 27 Geography students and 8 non-Geography students. Meanwhile, Hall-Wallace and McAuliffe (2002) used the whole classroom as their participants. In this study, there were 52 STPN students in total from STPN Yogyakarta (Table 3). It consisted of 1^{st} and 2^{nd} year students. Every year has around 80 students in total, for this thesis we sampled 40 1^{st} year students and 12 2^{nd} students respectively (Table 3). Meanwhile, our non-GIS student's participants were 43 students (Table 3) in which we did not make any different level based on the student's year grade.

The test for non-GIS students was conducted in Surakarta on 29 June 2015. Meanwhile, the test for GIS students was conducted in Yogyakarta on 30 June 2015. We did not conduct the spatial thinking pre-test using the translated test material. We directly performed the test using translated test material to our participants in Indonesia. The duration of the test was an hour to answer the 40 questions; it was the same as the previous test by Firdiansyah (2012). Furthermore, one of the recommendations for the test material by Firdiansyah (2012) which came from a participant was to use a computer or internet based test and not a test on paper. Hence, we used the computer laboratories in both locations and copied the material to the computers (Fig. 4). For GIS students, we performed the test simultaneously in three computer laboratories in which some teachers helped us supervising the students. In the other hand, we performed the test in two shifts for non-GIS students due to limited computers. There was no gap time between both shifts, thus the students did not have any chance to get any information related to the question of the test. We provided an answer sheet in which the participants wrote down the answers, an empty sheet, and stationery set for students doing the calculation when necessary. We also turned off the internet connection to avoid the possibility of the participants looking for the answer on the internet. Finally, we gave a short explanation about our spatial thinking test in geographical space , we asked the students to write their gender before the test was started, and asked the students to rank the difficulty of the test based on the choices given, i.e. very easy, easy, average, difficult, and very difficult.

3.3.4 Spatial thinking test scoring and analysis

After the spatial thinking test in Surakarta and Yogyakarta, we examined the test results of GIS and non-GIS students. For the scoring, we followed Firdiansyah (2012) in order to be able to make a one-one comparison with his result. We calculated the number of correct answers each student for each part of the test had and then calculated: 1) the percentage of correct answers per number of questions and mean score per part of spatial thinking test for GIS and non-GIS students, 2) the percentage of the total mean of correct answers of 1st year, 2nd year GIS students, non-GIS students, and 3) the percentage of the total mean of correct answers between GIS and non-GIS students. The percentages itself also showed the score, in which 100 was the highest score. Thus, the percentage of the total mean of correct answers represents also the total mean score. For analysis purpose, we compared the score of each part of the test, the score of the four sub-populations, the score between 1st and 2nd year of the STPN students (GIS), and the score between GIS and non-GIS students. Furthermore, we made a comparison in the order of spatial thinking test level and the percentage of mean score of each part between the study by Firdiansyah (2012) and this research. In addition, we presented a graph to show the participant's opinion about the difficulty of this test. Moreover, we analyzed the test result based on the gender. Research by Quaiser-Pohl, et al. (2006) and Neuburger, et al. (2014) showed that male students have a higher spatial ability than female students. Moreover, the spatial thinking test performed by Tomaszewski, et al., (2015) in Rwanda also showed that male students outperformed female students. To perform this test, we separated our test results based on gender for two of our groups: 1st year STPN students and the non-GIS students from the Informatics Engineering Diploma - Sebelas Maret University. We did not analyze the 2nd year STPN students, because this group of participants consisted only of 12 male students.

3.3.5 Spatial thinking test validation

The spatial thinking test validation aimed to validate that there was a mean score difference between the results of our populations and sub-populations. The validation of the test was carried out two times; i.e. the validation of the test result between the 1st and 2nd year STPN students (GIS students) and the validation of the test result between GIS and non-GIS students. Our validation followed Lee and Bednardz (2009, 2012) who used the independent sample t-test to analyze whether there is a statistically significant difference in the mean scores between the populations in their research, i.e. geography and non-geography major students. The independent samples t-test is very common to be used to evaluate the difference between the means of two independents or unrelated groups (Nthangeni and Algina, 2001; Ott and Longnecker, 2010). The number of samples for both populations in Lee and Bednardz (2009, 2012) was not the same. This corresponds with the number of samples that we used for validation, which was also not the same; we used all the test results of all the students as the sample for our test: 40 students of STPN 1st year and 12 students of STPN 2nd year for the first validation, and 52 STPN students (GIS) and 43 non-GIS students for the second validation. Moreover, in our independent samples t-test, we used a 2-tailed test with a 0.05 significance as used by Firdiansyah (2012).

3.3.6 Software

Most scoring and graphical plotting related to the spatial thinking test results were produced using Microsoft Excel. Most analysis related to test result validation was performed using SPSS Statistics software package. For the map production, we used the ArcGIS 10.2 software package (ESRI, Inc.).

4. Results

4.1 Observing pre-test of spatial thinking test material

We conducted a pre-test of the spatial thinking test material to five students from the GIS department of the Wageningen University-the Netherlands. The main purpose of the pre-test was to review the original test material and improve when necessary, i.e. question's clearness (pictures, graphs, sentences) (Appendix II). We also scored and calculate the pre-test results to know the final score of each pre-test participant and examined whether the mean score of each part had the same pattern with the previous test by Firdiansyah (2012) in which a higher level of spatial thinking resulted in a lower score.

4.1.1 Spatial thinking test material evaluation

We described to our participants to put attention at the test material layout, the clearness of the pictures and the level of readability of the graphs. The pre-test participants had unlimited time to perform the spatial thinking test in order to get detailed and critical feedback. In the end, we combined the feedback from the pre-test participants with the previous feedback from participants of the original spatial thinking test created by Firdiansyah (2012). Moreover we added our own evaluation to improve the spatial thinking test material. Table 6 shows the general overview of the comments and feedback given by the spatial thinking pre-test participants. We categorized the feedback given by the pre-test participants into five categories: layout, image's clearness, question's clearness, time required to finish the pre-test and overall feedback from each participant (Table 6).

Firstly, related to the layout, some pre-test participants said that it was quite disturbing when the pictures or graphs and related questions were not at one page. Based on this feedback, we made sure that the question and the corresponding picture or graph was at the same page (Appendix III, e.g. Part A no. 9 and 10). It was very useful since the test was examined on a computer; it helped the test participants to read the questions easier without the need to keep scrolling through the computer screen. Secondly, the pre-test participants stated that some pictures were too small, which made it not easy to make a difference in color and number. So, the pictures and graphs needed to be enhanced. Thus, we made the pictures larger than the original pictures in the test material (Appendix III, e.g. Part B no. 1, 2, 7, and 8).

Thirdly, the question's clearness was the category in which the participants gave most of their feedback. The questions that used a Minard chart (Appendix III Part A no. 7 and Part B no. 6) were the questions in which all pre-test participants could not understand the question. They stated that it was because there was no clear legend for these charts in the original test material. Thus, we added a legend for this chart by searching on the internet for more information about the Minard chart in this particular case. The legend for this chart presents by a red line the progress lane of Napoleon armies towards Russia and by the black line their retreat line (Appendix III Part A no. 7 and Part B no. 6). The other suggestions from pre-test participant were adding more pictures and reducing the sentences to make the questions easier to understand. It was in accordance with the suggestion of some participants in the previous test by Firdiansyah (2012). For instance, in Appendix III Part A no. 5, there is a sequence of pictures that shows a certain pattern. In order to make the question clearer, we added a box with a question mark as the sequence of the wind speed map (Appendix III Part A no. 5). We considered this method would make the question easier to understand.

The previous study done by Firdiansyah (2012), discusses the use of a common term i.e. a variance map by using Kriging. In his test, he described the definition of Kriging to make non-geography students easily understand the concept of this interpolation technique. However, he did not describe what variance was since he considered that variance was the common term that is well-known by everybody. However, two out of five participants from our pre-test stated that the meaning of variance in this context was not clear for them. Therefore, we improved the test by adding the definition of variance for this particular case (Appendix III Part D no. 1).

Fourthly, we asked our pre-test participants to count the time they needed to finish the test and write their feedback on it. One participant needed one hour to finish the test, three participants needed two hours, and one participant needed three hours to finish the test.

Finally, our pre-test participants gave their opinion about the general overview of the spatial thinking test by Firdiansyah (2012). The general opinion of the participants was that the test was too long, quite difficult, and many questions were not clear, therefore it was not easy to understand. Furthermore, they stated that it required a very good geographical knowledge and a high level of spatial thinking in order to answer the questions correctly. Several participants also stated there were two questions in Part D (Appendix III Part D no. 4 and 5) which had a very complicated calculation. They stated that it was impossible for them to solve this question without making use of a calculation tool, i.e. calculator.

Table 6. General overview of the most comments and feedbacks of spatial thinking pre-test.

Category	Participant's feedbacks
Layout	• Pictures/graphs that belongs to one questions should be in one page
Image's clearness (pictures and graphs)	• Pictures/graphs should be readable by enlarging them • Several pictures/graphs need an enhancement • Some maps need a legend
Question's clearness	• Many questions were not clearly formulated (e.g. questions related to Minard chart) • Several questions had too much text • Adding picture could improve the question
Time required to finish the pre-test	• Need one to three hours
Overall comments about the pre-test	• Quite difficult • Need a very good geographical background • Many unclear questions (Appendix III Part A no. 7; Part B no. 6 ; Part C no. 5 ; Part D no. 1, 3, 10) • Need a calculation tool because the questions were too difficult (Appendix III Part D no 4 and no. 5)

4.1.2 Spatial thinking pre-test scoring

After we reviewed the feedback for every question from the pre-test participants to improve our spatial thinking test material, we calculated the total mean score of the pre-test and the mean score of each part of the test. Besides to know the final score of each participant, we also examined whether the mean score of each part had the same rank with the test by Firdiansyah (2012) in which higher level of spatial thinking resulted in a lower score. Table 7 shows the percentage of correct answer per number of questions.

Table 7. Percentage of correct answers per number of questions and mean score of spatial thinking pre-test.

Question number	Primitive (Part B) (%)	Simple (Part D) (%)	Difficult/Complicated (Part C) (%)	Complex (Part A) (%)
		N=5		
Q1	80	20	80	100
Q2	20	60	40	100
Q3	80	20	100	60
Q4	80	60	60	0
Q5	60	0	80	0
Q6	40	60	80	20
Q7	80	40	100	20
Q8	80	100	100	60
Q9	100	60	20	100
Q10	20	0	80	80
Mean per part (%)	**64.00**	**42.00**	**74.00**	**54.00**
SD (%)	**15**	**18**	**11**	**11**
Total mean (%)			**58.50**	
SD (%)			**12.07**	

The result of the pre-test shows that the highest score in correct answers was the difficult/complicated level (Table 7). For those 10 questions on average 74% of the answers were correct, with a standard deviation of 11%. Moreover three out of the 10 questions, i.e. Q3, Q7, and Q8, were answered correctly by all participants. The category with the second highest score was the category Primitive. In this category 64% of the answers given by the pre-test participants were correct. The standard deviation belonging to this category is 15%. What is striking is that from the 10 easiest questions only one question was correctly answered by all five pre-test participants (Table 7). The third rank in the order as we can introduce them based on the pre-test participants is the category which should be the most complex. In this category the number of correct answers by the participants was wide-spread. Three out of the 10 questions were answered correctly by all participants. On the other hand, two questions were wrongly answered by all the participants. This led to a mean of 54% correct answers with a standard deviation of 11% (Table 7). The level simple had the lowest percentage of correct answers, with only 42% of correct answers and a corresponding standard deviation of 18%. What is even more striking for this category, which is considered as the second simplest category, is that question 5 and question 10 were wrongly answered by all participants (Table7).

Based on our pre-test results we can conclude that the order of the difficulty levels as assessed by Firdiansyah (2012) is different than the one we would make. Regarding to the pre-test results, the order from primitive to complex was Part C-B-A-D instead of Part B-D-C-A which Firdiansyah (2012) uses (Table 7). Therefore the category which is assessed as simple is based on those results the most complex category and the category which is assessed as difficult/complicated should be the most primitive category.

4.2 Observing spatial thinking test results of GIS and non-GIS students

We performed the spatial thinking test using the evaluated materials based on the pre-test in the Netherlands. Our population consisted of GIS and non-GIS students. In total, 95 students participated in this spatial thinking test. The sample size of our GIS-students consisted of 52 STPN students from STPN Yogyakarta. This group of GIS-students consisted of 40 1st year students and 12 2nd year students. Meanwhile, our non-GIS student participants had a sample size of 43 students.

4.2.1 Spatial thinking test result of GIS and non-GIS students

The general result of the spatial thinking test shows that the spatial thinking level of 2nd year GIS students is for all parts higher than for 1st year GIS students and non-GIS students (Table 8). The second rank is for 1st year GIS students; however the differences with non-GIS students are especially for the category simple and the category complex very small (Table 8). Those higher scores for 2nd year GIS students can be seen by the percentage of correct answers they had per category. The percentage of correct answers for the categories primitive, simple, difficult/complicated and complex were 49.17%, 50%, 53.33% and 52.50% respectively with a corresponding standard deviation of 17.29%, 17.58%, 18.26% and 12.15% respectively (Table 8).

Table 8. Percentage of correct answers per number of questions and mean score per part of spatial thinking test for GIS and non-GIS students.

Question number	Primitive (Part B) (%)			Simple (Part D) (%)			Difficult/Complicated (Part C) (%)			Complex (Part A) (%)		
	GIS		Non-GIS	GIS		Non-GIS	GIS		Non-GIS	GIS		Non-GIS
	1st	2nd		1st	2nd		1st	2nd		1st	2nd	
	N=40	N=12	N=43	N=40	N=12	N=43	N=40	N=12	N=43	N=40	N=12	N=43
Q1	80	75	65.12	35	41.67	23.26	57.50	58.33	44.19	57.50	41.67	79.07
Q2	30	25	27.91	47.50	83.33	51.16	55	50	48.84	57.50	50	23.26
Q3	35	33.33	27.91	10	8.33	18.6	70	75	72.09	42.50	75	20.93
Q4	27.50	66.67	23.26	25	33.33	34.88	35	33.33	39.53	12.50	41.67	27.91
Q5	55	41.67	32.56	70	25	16.28	35	41.67	27.91	20	33.33	20.93
Q6	52.50	25	34.88	35	75	32.56	77.50	83.33	62.79	40	75	27.91
Q7	52.50	75	58.14	15	16.67	6.98	55	66.67	46.51	40	58.33	44.19
Q8	42.50	50	34.88	52.50	75	39.53	42.50	58.33	37.21	10	33.33	9.30
Q9	65	83.33	39.53	40	83.33	67.44	5	8.33	18.60	52.50	41.67	76.74
Q10	25	16.67	27.91	15	58.33	53.49	52.50	58.33	25.58	27.50	75	30.23
Mean per part (%)	**46.50**	**49.17**	**37.21**	**34.50**	**50**	**34.42**	**48.50**	**53.33**	**42.33**	**36.25**	**52.50**	**36.05**
SD (%)	**20.70**	**17.29**	**15.17**	**12.39**	**17.58**	**13.51**	**20.58**	**18.26**	**18.50**	**16.44**	**12.15**	**11.78**

Those scores were higher than for the 1st year STPN students, which had following percentage per category question 46.50% for the primitive questions, 34.50% for the simple ones, 48.50% for the difficult/complicated question and 36.25% for the complex questions. The corresponding standard deviations were 17.29%, 17.58%, 18.26% and 12.15% respectively (Table 8). The lowest scores were for the non-GIS students from Informatics Engineering department of the state university in Surakarta-Central Java. The percentage of correct answers for the categories primitive, simple, difficult/complicated and complex that they scored were 37.21%, 34.42%, 42.33% and 36.05% respectively with a corresponding standard deviation of 15.17%, 13.51%, 18.50% and 11.78% respectively (Table 8). To determine whether the results of the spatial thinking test are statistically significant we have to perform some statistical analysis, which will be described later on in this thesis.

Moreover, Figure 5 shows the percentage of correct answers of each part of the test as we can see in Table 7 and Table 8. If we include our pre-test participants from the Netherlands (MGI students), it is clearly shown that they had the highest score although there are four questions in the test in which none of the students of the MGI group could answer the question correctly (Fig. 5). However, if we only consider our GIS and non-GIS participants, we can see that overall, the 2nd year STPN had higher scores than the others.

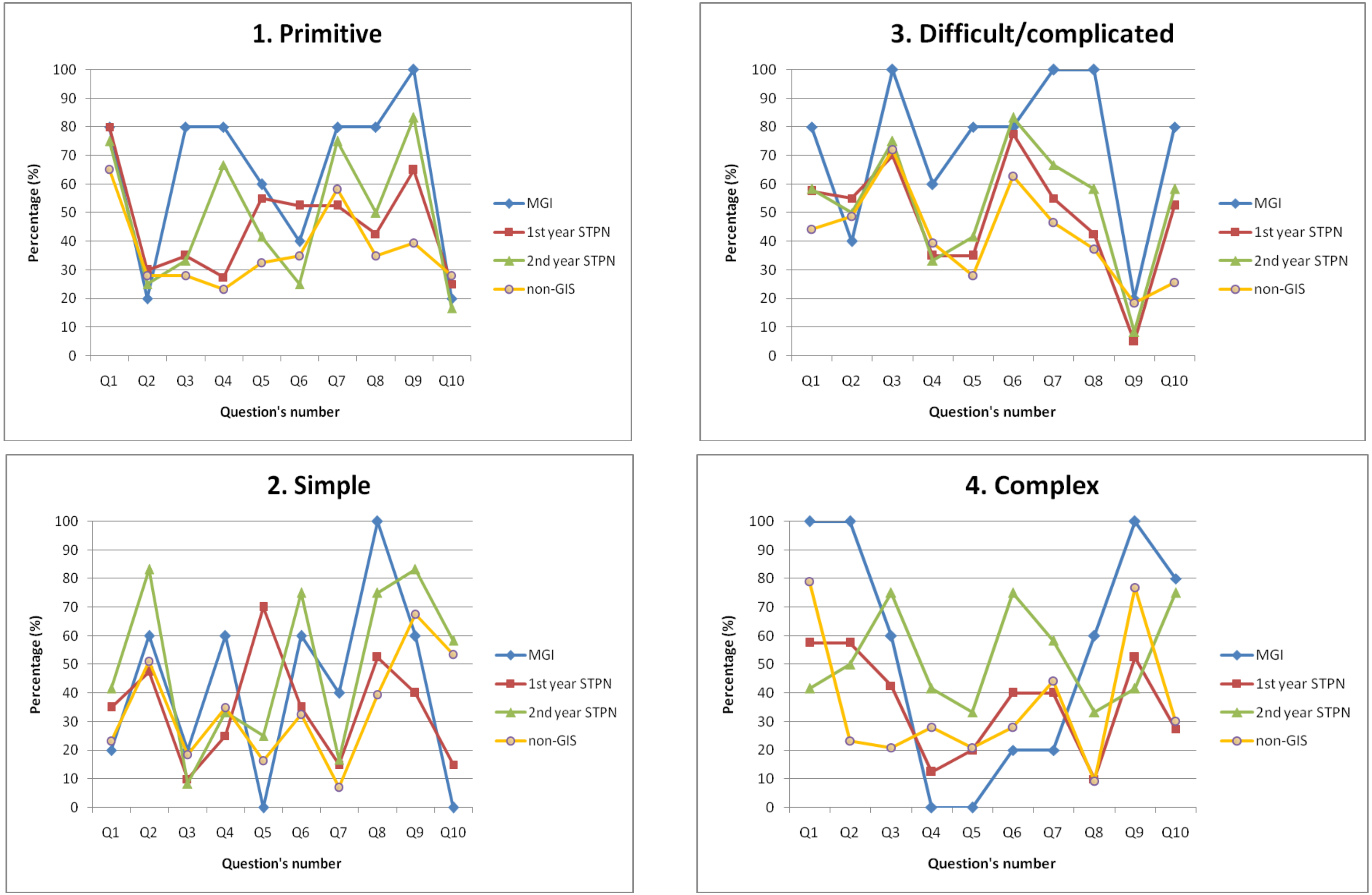

Figure 5. Percentage of correct answers of the four parts of the test. These graphs show the result of all our participants, from both the spatial thinking pre-test in the Netherlands and the spatial thinking test in Indonesia.

As discussed earlier, the 2nd year STPN (GIS) students had the highest percentage of correct answers with a percentage of 51.25% and a standard deviation of 11.80% (Table 9). The second rank is for 1st year STPN students with a percentage of correct answers of 41.44 and a standard deviation of 10.14%. The third rank is for the non-GIS students from the Informatics Engineering Diploma – Sebelas Maret University (Table 9). They had on average 37.5% of the questions correct with a standard deviation of 7.05%. However, if we add the Geo-Information Science students from the Wageningen University who participated in the pre-test, we discover that they had the highest percentage of correct answers to the spatial thinking test. They answered on average 58.5% of the questions correct with a corresponding standard deviation of 12.07% (Table 9). However, we have to make a remark for this group that they had more time to answer the questions, compared to the STPN students and the non-GIS students who had only one hour to answer the questions.

Table 9. The comparison of the percentage of the total mean of correct answers of four groups.

	N	Total mean (%)	SD (%)
MGI	5	58.50	12.07
GIS			
• **1st year**	40	41.44	10.14
• **2nd year**	12	51.25	11.80
Non-GIS	40	37.50	7.05

Table 10 shows the percentage of correct answers for all questions in all categories for GIS and non-GIS students. This percentage, which is considered as the overall mean percentage, corresponds to the mean score for both groups. We combined and calculated the mean score of 1st and 2nd year STPN students (GIS) resulted in a mean score of 43.70. This score was higher than the mean score of non-GIS students, which was 37.50 (Table 10).

Table 10. The comparison of the percentage of the total mean of correct answers between GIS and non-GIS students.

	N	Total mean (%)	SD (%)
GIS (STPN)	52	43.70	11.23
Non-GIS	43	37.50	7.05

If we want to assess the spatial thinking level based on the categories which had been developed by Firdiansyah (2012), we run into the same problems as what we already discovered when assessing the pre-test. The primitive or simple categories were not recognized as the easiest categories by the participant of the test (Table 11). The same was true for the difficult/complicated and complex level, those were also not recognized as the hardest categories based on the results of the test (Table 11). Therefore we made Table 11, a ranking in the level based on the percentage of correct answers given by the participants of the spatial thinking test. The 1st year GIS students (STPN) and the non-GIS students from the Informatics Engineering Diploma of the state university in Surakarta-Central Java follow the same rank as discussed earlier for the MGI students from the Wageningen

University (Table 11). Those groups had the highest percentage of correct answers for the level difficult/complicated and the lowest percentage of correct answers for the level simple. However, this level should the second easiest category of spatial thinking based on the study by Firdiansyah (2012) (Table 11). The results of the 2nd year GIS-students (STPN) deviated from the results obtained from the spatial thinking tests for the other subpopulations. In this subpopulation, again the questions belonging to the level difficult/complicated are the easiest questions with the highest percentage of correct answers. However this group had the most difficulties with the primitive questions, which should be the easiest questions based on the study by Firdiansyah (2012) (Table 11). Overall we can conclude that the levels of spatial thinking recognized by Firdiansyah (2012) do not correspond with the results we obtained from the spatial thinking test for the STPN students and the non-GIS students.

Table 11. The comparison of the rank of spatial thinking test level and the percentage of mean score of each part between the study by Firdiansyah (2012) and this research. The rank of the spatial thinking level test result shows the highest to the lowest score, the higher spatial thinking level results in less score (1 represents the lowest spatial thinking level and 4 represents the highest spatial thinking level based on Firdiansyah (2012)).

	N	The rank of spatial thinking level based on mean scores			
		1	**2**	**3**	**4**
1. Firdiansyah (2012)					
• **Univ A**	19	Primitive 51	Simple 38	Difficult/Complicated 36	Complex 33
• **Univ B**	8	Primitive 84	Simple 74	Difficult/Complicated 66	Complex 60
• **Univ C**	8	Primitive 61	Simple 51	Difficult/Complicated 48	Complex 40
2. This research					
• **MGI**	5	Difficult/Complicated 74.00	Primitive 64.00	Complex 54.00	Simple 42.00
• **GIS 1st year**	40	Difficult/Complicated 48.50	Primitive 46.50	Complex 36.25	Simple 34.50
• **GIS 2nd year**	12	Difficult/Complicated 53.33	Complex 52.50	Simple 50	Primitive 49.17
• **Non-GIS**	43	Difficult/Complicated 42.33	Primitive 37.21	Complex 36.05	Simple 34.42

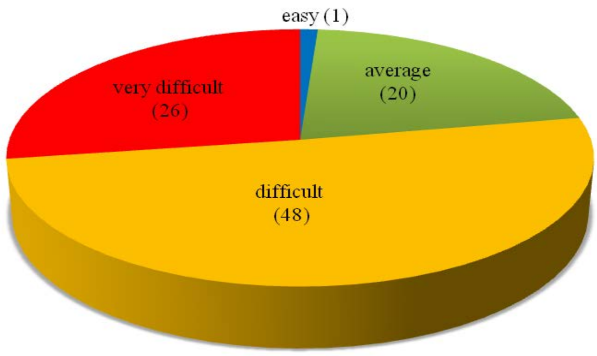

Figure 6. The number of participant's opinion about the test's difficulty.

In addition, we asked the participants to rank the test difficulty from the choices given, i.e. 1) very easy, 2) easy, 3) average, 4) difficult, and 5) very difficult. Figure 6 reveals how the 95 GIS and non-GIS students ranked the test. Overall, only one of the participants considered the test as easy. Furthermore, 48 participants (51%) agreed that the test was difficult and even 26 out of the 95 participants (27%) considered that the test was very difficult. There were 20 participants who considered that the test difficulty was average (Fig. 6).

4.2.2 Spatial thinking test result validation

Our validation aimed to validate whether there was a statistically significant mean score difference between the results of sub-populations. The validation of the test was carried out two times; i.e. the validation of the test result between the 1st and 2nd year STPN students (GIS students) and the validation of the test result between GIS and non-GIS students. We used an independent samples 2-tailed t-test with a significance of 0.05 as used by Firdiansyah (2012).

Table 12 shows the output of the independent samples t-test between 1st and 2nd year STPN students. This statistic test result was used to validate our previous finding as shown in Table 9. We started our statistical analysis by defining our H_0 and H_a. For this particular test, the H_0 was defined as No difference in the mean score between the 1st and 2nd year STPN students. In the alternative hypothesis H_a, it was stated that there is a significant difference between 1st year and 2nd year STPN students. Since we were not sure whether we could expect that 2nd year students have a high score than 1st year we decided to use a two sided rejection region. Next, we used the Levene's Test for Equality of Variances. The outcome of this Levene's test had a significance of 0.667 (Table 12). Since this value is greater than .05, we can assume that the variability in our two sub-populations is about the same, which means we can use the first row in Table 12. Thus, the t-value as the outcome of our t-test for Equality of Means was -2.823 with a significance of 0.007 (Table 12). A significance of 0.007, which is smaller than α (= 0.025 (= 0.05/2)), which means that the hypothesis H_0 that there is no difference in the mean score between the 1st and 2nd year STPN students was rejected and our alternative hypothesis H_a that there is a significant difference between 1st year and 2nd year STPN students was accepted.

Table 12. Independent samples t-test between 1st and 2nd year STPN students.

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Score	Equal variances assumed	,187	,667	-2,832	50	,007	-9,8125
	Equal variances not assumed			-2,607	16,192	,019	-9,8125

Therefore we are able to state that the mean score for the spatial thinking is significantly different between 1st and 2nd year STPN students.

Furthermore, Table 13 shows the output of the independent samples t-test between GIS and non-GIS students. This statistical test was done to prove that there is a significant difference between GIS students from STPN and non-GIS students from the Informatics Engineering Diploma of the state university in Surakarta-Central Java. We started our statistical analysis by defining our H_0 and H_a. For this particular test, the H_0 was defined as No difference in the mean score between GIS and non-GIS students. In the alternative hypothesis H_a, it was stated that there is a significant difference between GIS and non-GIS students. Since we were not sure whether we can expect that GIS-students have a high score than non-GIS students, we decided to use a two sided rejection region. Before we applied the t-test for equality of means, we needed to determine whether we can assume equal variance. Therefore, we used the Levene's Test for Equality of Variances. The outcome of this Levene's test had a significance of 0.006 (Table 13). Since this value is smaller than .05, we cannot assume that the variability in our two sub-populations is about the same. So we used the second row in Table 13. Thus, the t-value as the outcome of our t-test for Equality of Means was 3.277 with a significance of 0.002 (Table 13).

Table 13. Independent samples t-test between GIS and non-GIS students.

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Score	Equal variances assumed	7,837	,006	3,144	93	,002	6,2019
	Equal variances not assumed			3,277	87,159	,002	6,2019

A significance of 0.002, which is smaller than α (= 0.025 (= 0.05/2)), which means that the hypothesis H_0 that there is no difference in the mean score between the GIS and non-GIS students was rejected and our alternative hypothesis H_a that there is a significant difference between GIS and non-GIS students was accepted. Therefore we can conclude that this t-test for equality of means confirms that GIS students from STPN and non-GIS students from the Informatics Engineering Diploma of the state university in Surakarta-Central Java have a statistically significant different result.

4.2.3 Spatial thinking test result based on the gender

Besides comparing the overall test result of STPN and non-GIS students, we also analyzed the test result based on the gender. Table 14 shows the mean score based on gender for the 1st year STPN students. The mean score of the male students was 41.522 and the mean score of the female students was 41.324. We might assume that the male students of the 1st year STPN have more spatial knowledge than the female students. However, to test whether this difference is statistically significant, we performed an independent samples t-test.

Table 14. Mean of correct answers based on the gender of the 1st year STPN students.

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Score	Male	23	41,522	10,0775	2,1013
	Female	17	41,324	10,5370	2,5556

Table 15 shows the output of the independent samples t-test between male and female students of the 1st year STPN students. Our hypothesis (H_0) was that the mean score between male and female students of the 1st year STPN is the same. Our alternative hypothesis (H_a) states that there is a significant difference between the two sexes. First we started by applying the Levene's test, to test whether there we can assume equal variances or not. The outcome of the Levene's test had a significance of 0.615 (Table 15). Since this value is higher than .05, we can assume that the variability in our two sub-populations is about the same. So we could use the first row in Table 15. Thus, the t-value as the outcome of our t-test for Equality of Means was 0.060 with a significance of 0.952 (Table 15). A significance of 0.952, which is higher than α (= 0.025 (= 0.05/2)), which means that the hypothesis H_0 that there is no difference in the mean score between the male and female students of the 1st year STPN was accepted and our alternative hypothesis H_a that there is a significant difference between the male and female students of the 1st year STPN was rejected.

Therefore we can conclude that this t-test for equality of means confirms that male students and female students of the 1st year STPN do not have a statistically significant different result. So the higher score for male students which was found in this thesis could be the result of coincidence. If we would perform the test another time, it could be that female students would have a higher spatial thinking score. Therefore based on the results of this thesis, we cannot conclude that male students have in general a significantly higher spatial thinking level than female students.

Table 15. Independent samples t-test based on the gender of the 1st year STPN students.

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Score	Equal variances assumed	,257	,615	,060	38	,952	,1982
	Equal variances not assumed			,060	33,734	,953	,1982

Meanwhile, Table 16 shows the mean score based on the gender of the Informatics Engineering Diploma of the state university in Surakarta-Central Java (non-GIS students). The mean score of the male students was 38.600 and the mean score of the female students was 35.972. We might assume that male students of the non-GIS have a higher understanding of spatial thinking than female students. However, to test whether this difference is statistically significant, we performed an independent sample t-test again for these groups.

Table 16. Mean of correct answers based on the gender of non-GIS students.

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Score	Male	25	38,600	7,9412	1,5882
	Female	18	35,972	5,4327	1,2805

Furthermore, Table 17 shows the output of the independent samples t-test between male and female students of the non-GIS students. Our hypothesis (H_0) was that the mean score between the male and female students of the non-GIS students is the same. Our alternative hypothesis (H_a) states that there is a significant difference between the two sexes. First we started by applying the Levene's test, to test whether there we can assume equal variances or not. The outcome of this Levene's test has a significance of 0.104 (Table 17). Since this value is higher than .05, we can assume that the variability in our two sub-populations is about the same. So we will use the first row in Table 17. Therefore, the t-value as the outcome of our t-test for Equality of Means was 1.213 with a significance of 0.232 (Table 17). A significance of 0.232, which is higher than α (= 0.025 (= 0.05/2)), this means that the hypothesis H_0 that there is no significant difference in the mean score between male and female students of Informatics Engineering Diploma of the state university in Surakarta-Central Java was accepted and our alternative hypothesis H_a that there is a significant difference between male and female students of non-GIS group was rejected.

Table 17. Independent samples t-test based on the gender of non-GIS students.

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Score	Equal variances assumed	2,763	,104	1,213	41	,232	2,6278
	Equal variances not assumed			1,288	40,928	,205	2,6278

Therefore we can conclude that this t-test for equality of means confirms that male students and female students of the Informatics Engineering Diploma of Sebelas Maret University do not have a statistically significant different result.

5. Discussion

5.1 The quality of spatial thinking test material

According to NRC (2006) and Lee and Bednarz (2012), there is no comprehensive spatial thinking test material to measure the spatial thinking ability in geographical scale. Thus, in 2012, Firdiansyah (2012) developed a spatial thinking test to examine the spatial thinking level in the geographical space as referred to NRC (2006) and Golledge et al. (2008a, 2008b). From four levels of spatial thinking by NRC (2006) and five levels of geospatial concepts proposed by Golledge et al. (2008a, 2008b) (Table 1), Firdiansyah (2012) used four levels: 1) primitive, 2) simple, 3) difficult/complicated, and 4) complex. Moreover, in the test material developed by Firdiansyah (2012), he used the concepts by NRC (2006) as the basis for his spatial thinking levels which also confirmed 16 out of the total of 24 geospatial concepts used by Golledge et al. (2008a) in the four spatial thinking levels which were developed by this author.

The feedback from our spatial thinking pre-test in the Netherlands (Table 6) showed that from the layout and question's clearness aspect, the test material developed by Firdiansyah (2012) is quite good and only need more improvement to make it more clear than the original one, e.g. the questions with the Minard chart (Appendix III Part A no. 7 and Part B no. 6). However, our participants stated that there were some questions which had a very difficult calculation, i.e. questions at Appendix III Part D no. 4 and 5. It resulted in the fact that no one could answer the question at Part D no. 5 even though we provided them unlimited time to do the test.

Furthermore, the pre-test mean scores for each part of the test have a different rank compared with Firdiansyah (2012), the order does not show that the higher spatial thinking levels lead to a lower score (Table 11). Our participants considered Part D (simple level) as the most difficult one, because those questions included many difficult calculations as we mentioned before. If we see the concepts in Part D used by Firdiansyah (2012), i.e. class/group, boundary, and scale for the simple level (Table 4) and Table 7 and Fig. 5, we can see that our pre-test participants had difficulties in answering questions with the class/group concept (Appendix III Part D no. 5) and questions with the representation of geospatial features (Appendix III Part D no. 10). The mean score of the spatial thinking pre-test by five MGI students in the Netherlands is 58.50 (Table 7 and Table 9), this result is bit higher than the eight non-geography students who had a score of 50.00 and much lower compared with the geography students who had score of 71.00 in Firdiansyah (2012).

Although our main purpose of the pre-test was to review the original test material and improve when necessary, i.e. question's clearness (pictures, graphs, sentences), we can see that even with the unlimited time for the spatial thinking pre-test, the result of the five MGI students in the Netherlands does not follow the spatial thinking level determined by Firdiansyah (2012). It might be caused by different number of the participants between this research and the previous one, that might result in a different score (Lee and Bednarz, 2012).

5.2 The relationship between GIS learning level and spatial thinking ability in understanding geographical space

STPN is a school under the NLA authority whose main task is to organize education programs in land matters. Hence, it is very important for Diploma IV STPN students to understand the geographical space, e.g. coordinate system, projection system, boundary, direction, etc, in order to avoid land disputes that might happen from the publication of land certificates. In the STPN curriculum, GIS, cartography, cadastral measurement and mapping, land information system, become main technical courses to support its main core: land administration and land management. It is expected that the students will gain more knowledge in the field of GIS to support their work in the NLA offices all over Indonesia. The higher the grade of the Diploma IV the more learning outcomes related to GIS they should be achieved.

Although the developed spatial thinking test by Firdiansyah (2012) does not have all geospatial concepts as determined by Golledge et al. (2008a), we still considered that performing the spatial thinking test for the geographical space is able to examine the 1^{st} and 2^{nd} year Diploma IV students ability in several geospatial concepts. In the other words, we evaluated the learning outcomes of the 1^{st} and 2^{nd} year Diploma IV students using a limited set of closed questions. The population of STPN students consisted of 40 1^{st} year students and 12 2^{nd} year students (Table 3). Our spatial thinking test result showed that 2^{nd} year students scored better than the 1^{st} year (Table 8; Table 9; Fig. 5). This result was confirmed by the result of the independent samples t-test in Table 12. The table shows that the mean score of both subpopulations had a statistically significant difference. This result might be caused by the fact that the 2^{nd} year students already studied about more topics related to GIS, i.e. digital data processing, cartography, remote sensing, GIS, and cadastral measurement and mapping, than the 1^{st} year students who only learned about digital data processing and cartography. It means that the 2^{nd} year students already achieved more learning outcomes than the 1^{st} year students as described in section 2.4. Our result is in accordance with the result of Lee and Bednarz (2009) whose result shows that students who follow more GIS courses, i.e. GIS and cartography, have a significant higher test score than students who only take a GIS or cartography course and not both of them.

Furthermore, an interesting finding from the test result of the 1^{st} and 2^{nd} year students of STPN is that the rank of their spatial thinking level, assessed by the total mean score of each part of the test, does not follow Firdiansyah (2012) results. The rank of the spatial thinking level of the 40 1^{st} year students was the same with the five MGI students from the pre-test in the Netherlands and the 43 non-GIS students (section 5.3) who had the highest score in the difficult/complicated level and the lowest score in the simple level. Meanwhile, the 12 2^{nd} year students had the highest score in the difficult/complicated level and the lowest score in the primitive level (Table 11). The fact that the simple and the primitive level are the two levels with the lowest score in this study might be caused by several factors. Firstly, it might be that the questions for the simple and primitive level are too difficult or not clear. However, we assume that unclearness should be avoided after improving the test with the feedback from the pre-test participants. Even after improving the questions clearness and translating it to the Indonesian language it has still the low scores. Another reason what might be the cause of the low scores for this category is that the geospatial concepts included in the simple and primitive levels do not get enough attention in the curriculum of their study. Moreover, there is also a possibility that for instance the 2nd year STPN students, whose primitive level's score is the lowest one, already forget the most simple geospatial concepts since they have different learning outcomes to be achieved in the 2nd year of their study.

Table 8 and Figure 5 show us that although in general the 2nd year students have a higher score than the 1st year students, the 2nd year students have difficulties in answering questions with the identity (map primitives) concept, in which students should be able to understand the phenomena from the map given (Appendix III Part B no. 2). Moreover, they had difficulties with the questions about the Minard chart as the representation of the spatio-time concept (Appendix III Part B no. 6) and questions about latitude and longitude determination as the representation of the magnitude concept (Appendix III Part B no. 10). Meanwhile, the 1st year students have difficulties in answering the simple level that includes the concepts: class group, boundary, scale. Table 8 and Figure 5 show that the 1st year students have difficulties in answering questions with the boundary concept (Appendix III Part D no. 3).

Based on the test results and description that the 1st and the 2nd year students have some difficulties in the lower spatial thinking levels, we might put attention to the STPN curriculum and learning outcomes and objectives for the 1st and 2nd year level as described in section 2.4. If we compare between the learning outcomes – learning objectives and the Bloom's taxonomy which represents the level of learning outcomes in cognitive domain (section 2.3), we might observe that mainly the lower cognitive levels are addressed in the first three years and not in the 4th year. The first three years include mainly the cognitive levels of knowledge, comprehension, and application. Meanwhile, in the 4th year, the curriculum has higher cognitive levels, synthesis and evaluation, in which the students have to establish a Land Information System and use it as a decision support tool in land matters. These facts might affect the spatial thinking level of the STPN students, in which the lower level students with a lower level of learning outcomes in the cognitive domain resulted in the lower spatial thinking levels.

5.3 The comparison of spatial thinking ability between GIS and non-GIS students in understanding geographical space

We performed the spatial thinking test in geographical space to 52 STPN students from STPN Yogyakarta (GIS students) and 43 students from Sebelas Maret University (UNS) - Informatics Engineering Diploma (non-GIS students). Our result in Table 10 and Table 13 show that GIS students had a higher score (43.70) than the non-GIS students (37.50). Our result is in line with Firdiansyah (2012) in which his geography group has a total mean score of 71 and the non-geography group has a score of 50. It is also in accordance with Lee and Bednarz (2012) whose results also showed that the geography major has a higher score than the non-geography major.

Based on our results, we can conclude that STPN students have a better spatial knowledge than the non-GIS students from Sebelas Maret University (UNS). Furthermore, we might assume that knowledge about GIS will increase student's development in spatial abilities because they have to know the concept of space, i.e. scale, projection, geometry, and topology, as stated by Self et al. (1992). Furthermore, we can conclude that GIS learning improves the ability in spatial visualization, spatial reasoning, and map reading skills (Hall-Wallace and McAuliffe, 2002; Hagevik, 2003; Forer and Unwin, 1993).

An interesting finding from the test result of GIS and non-GIS students is that the rank of their spatial thinking level, assessed by the total mean score of each part of the test, does not follow the rank established by Firdiansyah (2012). The order of the spatial thinking level of the 43 non-GIS students was the same as the MGI students from the Netherlands and the 1st year STPN students. Those three groups had the highest score in the difficult/complicated level and the lowest score in the simple level (Table 11).

Overall, the ranks of the spatial thinking level for our four subpopulations were different compared to Firdiansyah (2012) (Table 11) as we described in section 5.1, 5.2 and 5.3. Based on this result, we may conclude that the ranks in the levels of the spatial thinking test developed by Firdiansyah (2012) are not relevant to be applied for our population.

5.4 The relationship between gender and spatial thinking ability in understanding geographical space

We analyzed the test result based on the gender for two of our subpopulations: 1st year STPN students and non-GIS students from the Informatics Engineering Diploma of the state university in Surakarta-Central Java. Our results showed that for both groups, the male students scored higher than the female students (Table 14 and Table 16). However, our independent samples t-test showed that male and female students of the 1st year STPN did not have a statistically significant different result (Table 15). Therefore we cannot conclude that male students have in general a significantly higher spatial thinking level than female students. Our result is not the same with the research's results by Quaiser-Pohl, et al. (2006), Neuburger, et al. (2014) and Tomaszewski, et al., (2015) in which their results showed that male students have a significant higher spatial ability than female students.

We correlate the statistic result that male students and female students of the 1st year STPN did not have a statistically significant different result with several factors about this group. Firstly, both male and female students of the 1st year STPN already worked for some period in the NLA offices before they get the scholarship and study in STPN. Most of the students are trained to work for the measure and mapping department. It means that either male or female students have working experiences that involve GIS applications in land parcel measurement and mapping. Secondly, the Diploma IV students were the students of Diploma I in STPN before they got a scholarship for Diploma IV. This circumstance makes the male and female students having an equal knowledge by following the courses in Diploma I of STPN. These factors might be the reason that the test results of male and female students of the 1st year STPN did not have a statistically significant different score.

For the non-GIS students we found comparable statistic results, in which it was shown that male students and female students did not have a statistically significant different score (Table 17). We assume that there is no difference in the results between both genders because the Indonesian education policies state that both male and female students need to have the same access in attending school (Kristiansen and Pratikno, 2006). It can be seen from the ratio of gender balance which shows that “the gender balance at lower levels of education has been remarkably good” (Kristiansen and Pratikno, 2006). Another factor that might affect this result is the fact that both male and female students of Informatics Engineering Diploma – Sebelas Maret University are familiar with courses which involve computer programming, in which according to Clements and Gullo (1984) and Liao and Bright (1991), computer programming can increase problem-solving and spatial ability, which might be helpful while performing a spatial thinking test.

This test results might be used as the input for STPN senate, STPN staffs, STPN teachers and the students, since the STPN students also become the future NLA officers who always concern about land matter in Indonesia and those who will always work with various maps and locations in land certificate processes. For the STPN senate and staffs, it is important to support the study activities by providing adequate facilities for the students, so they will be able to explore more concepts of the geographical space, e.g. good computers with adequate software in the computer laboratories. Furthermore, the STPN teachers and those who arrange the STPN curriculum should put more attention to the basic geospatial concepts and make sure that the students achieved those learning outcomes with sufficient results. Finally, the STPN students should be more aware with geographical spaces in their study and job, e.g. retrieving information from maps, understanding specific location in longitude and latitude, defining the area boundaries, etc, because NLA concerns in land registration that determines the legal matter of the land parcels. If the STPN students have good understanding in geographical spaces, it can be expected that the NLA will be able to avoid land disputes and conflicts in the future.

6. Conclusions and Recommendations

6.1 Conclusions

In this section, an overview of conclusions about the main findings related to spatial thinking between GIS and non-GIS students is provided. It also addresses the results for each research question formulated at the beginning of this study. The conclusions are presented below:

Question: "Can the test developed by Firdiansyah (2012) used for finding the relationship?"

Firdiansyah (2012) developed and performed a spatial thinking test in the Netherlands to 35 participants. His results showed that he successfully developed a spatial thinking test in geographical space, which made use of differences in the ranks of the spatial thinking levels. The rank of spatial thinking levels ranging from the lowest to highest level was primitive-simple-difficult/complicated-complex, in which a higher spatial thinking level resulted in a lower score by the participants. Our spatial thinking pre-test in the Netherlands with five participants and the spatial thinking test in Indonesia with 95 participants showed different ranks compared to Firdiansyah (2012). We had two different ranks for our four subpopulations. Firstly, the rank from the lowest to highest level for the subpopulation of MGI, 1st year STPN and non-GIS students was difficult/complicated-primitive-complex-simple. Meanwhile, the rank of the 2nd year STPN students was difficult/complicated-complex-simple-primitive. Based on this result, we may conclude that the ranks in the levels of the spatial thinking test developed by Firdiansyah (2012) are not relevant to be applied for our population.

Question: "What relationship does exist between GIS learning levels (outcomes) and spatial thinking levels of STPN students?"

We investigated the relationship between GIS learning level and the spatial thinking level of the 1st and 2nd year STPN students. The results showed that the 2nd year students outperformed the 1st year students. The independent sample t-test confirmed this, with a significance of 0.007. Based on this result, we conclude that the 2nd year students have a higher spatial thinking level than 1st year STPN students. Furthermore, we might conclude that a higher GIS learning level which means more GIS learning achieved, leads to better spatial abilities achieved by the students. However, our result showed that the 2nd year students had the lowest score in the primitive level which was considered as the easiest part and the 1st year students had the lowest score in the simple level which was considered as the level directly derived from the primitive level. We might assume that both subpopulations need more attention in the basic geospatial concepts.

Question: "Do spatial thinking levels of STPN (GIS) students differ from non-GIS students?"

The spatial thinking test results showed that STPN students scored higher than non-GIS students, with a score of 43.70 for GIS students and 37.50 for Non-GIS. We applied an independent samples t-test with a 0.05 significance, to check whether there was a statistically significant difference between the STPN and non-GIS students. This was proven by a significance of 0.002, therefore we can safely conclude that the spatial thinking level of GIS students is higher than the non-GIS students which means that STPN students have more spatial knowledge than the non-GIS students.

Question: "Will female students perform different than male students considering spatial thinking?"

We analyzed the effect of gender on the spatial thinking levels for 1st STPN-students and for non-GIS students. We observed a slightly higher score in the mean score for male students for both groups. We applied an independent sample t-test with a 0.05 significance, to check whether there was a statistically significant difference between male and female students for both 1st STPN-students and non-GIS students. The difference between male and female students was for both groups not significant with a significant of 0.952 and 0.232 respectively. Therefore we can conclude that there are no significant differences in the results of the spatial thinking test between male and female students for both the STPN and the non-GIS group.

6.2 Recommendations

Based on our results and conclusions during this study, we recommend several recommendations to be considered in the future.

Firstly, the spatial thinking test should be improved or updated. Since the ranks in the levels of the spatial thinking test developed by Firdiansyah (2012) are not relevant to be applied for our population, it is necessary to update and improve the test. This improvement might be done by using more geospatial concepts in the spatial thinking test for the geographical space. Another useful addition would be the implementation of some questions related to the ability to identify a two-dimensional cross section of a three-dimensional geometric solid. According to Cohen and Hegarty (2012), this skill has been identified as important in the fields of science, technology, engineering, and mathematics (STEM). Cohen and Hegarty (2012) performed successfully such a spatial thinking test that assesses the ability to identify the two-dimensional cross section of a three-dimensional geometric solid. The results of this test showed that high spatial participants, participants whose spatial thinking level was assumed to be high, outperformed low spatial participants. Another improvement related to the spatial thinking test material might be updating the test, not only the closed questions in the test but also add a performance task like what Lee and Bednardz (2009) did. An example of such a performance task would be that the students are required to perform several tasks related to "imagining maps from verbal descriptions" (Golledge and Stimson, 1997). These improvements might be considered for future research related to spatial thinking tests.

Secondly, the spatial thinking level assessment should become a more comprehensive assessment. In order to examine and analysis the relationship between GIS learning and the spatial thinking ability, it requires a comprehensive assessment and analysis (Lee and Bednardz, 2009). It can be achieved by correlating the spatial thinking test result with the student marks in a certain study period time: average lab-score, mid-term mark, and final exam grade (Lee and Bednardz, 2009). This comprehensive assessment and analysis might be a topic for next studies.

Thirdly, in a next study about assessing the spatial thinking level of a population, it can be useful to include some other factors to create different subpopulations. Some factors that can be useful have been studied in the paper of Tomaszewski et al. (2015). In this paper, Lee and Bednarz's (2012) Spatial Thinking Ability Test (STAT) had been used to assess whether there is a difference in spatial thinking between students from rural and urban secondary schools in Rwanda. Statistical analysis in their research revealed that urban school students performed significantly better than rural school students. Therefore for a next study about spatial thinking between GIS and non-GIS students, it can be wise to include factors like origin.

Fourthly, due to the relatively low scores in the basic geospatial concepts, a recommendation from our side would be to improve the STPN curriculum (learning outcomes, learning objectives, learning materials, and learning activities) especially for the lower years in the Diploma IV curriculum. The STPN staff and STPN teachers who concern about the curriculum development might pay attention to the Bloom's taxonomy, which represents the level of learning outcomes in the cognitive domain, and might use it as a reference and consideration during the curriculum establishment. We recommend that each year of the STPN curriculum has specific learning outcomes, learning objectives, learning material, and learning activities that accommodate each cognitive level. Hence, it is expected that STPN students will learn the GIS-related courses in a comprehensive way and might increase their spatial thinking ability.

In conclusion, by combining all our results in this study, it gives many opportunities for NLA especially the STPN to evaluate their curriculum and study activities. The STPN staff, teachers, and also the students should give more attention to the basic learning outcomes. A continuously development in the STPN curriculum is necessary for NLA and STPN to gain a high qualified human source in land management and land administration.

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Appendixes

Appendix I. The content and description of the spatial thinking in geographical space test material. Source: Firdiansyah (2012).

Part of the test	Description
Part A	“The first part examines the participants’ abilities in manipulating and transforming the space that has been constructed. The participants’ abilities in interpreting the relations amongst objects are tested. The first part will examine the complex spatial concepts possessed by the participants. It represents the highest degree of spatial thinking that requires the participants to have well comprehension of spatial thinking. Four spatial concepts are tested in the first part. They are spatial reasoning, map projection, overlay and spatial association. Spatial reasoning is included in this part in order to verify the ability to infer a spatial reasoning from a mapped object. Map projection and overlay are included in this part in order to observe the ability to manipulate and transform the spatial datasets using specific spatial operations. Lastly, spatial association is asked in order to check whether the participants comprehend spatial association as one of spatial concept identified by Golledge (2002)”.
Part B	“The second part is to evaluate the participants’ abilities in capturing surrounding objects (occurrences or phenomena). Primitive spatial concepts are employed as the basis of the questions, such as map primitives (identity), magnitude, location and spatio-temporal of an occurrence. Four parts of questions are created to incorporate the spatial concepts. First, the ability of identifying the primitives (features) within a map of certain phenomena is examined. The participants are expected to identify specific features that can be included or excluded in the making of a map. Second, the participants shall indicate the magnitude of an occurrence. By providing a map in which the information can be inferred from the way of mapping, the participants are inquired specific information. Third, the participants shall be able to use latitude-longitude system in drawing a conclusion regarding a place. They will be presented a map with a latitude-longitude system and they have to think about which area where no longitude may be given. In order to solve the problem, the participants shall draw imaginary lines running north-south around the globe and think where the lines may converge. Lastly, the participants shall understand spatio-temporal phenomena that can be concluded from a map. Minard’s chart depicting the disastrous march of Napoleon to Moscow in 1812 created by Stanford University is presented. The participants are then asked when an occurrence happened based on information in the map. Other questions will check the ability of the participants in capturing specific information by using several maps”.

Part of the test	Description
Part C	“Next, the participants shall be able to obtain and draw a sequence of spatial concepts and relations of the observed objects with their surroundings. Five spatial concepts that are considered as difficult and/or complicated spatial concepts by Golledge (2008a) are used, i.e. coordinate, direction (orientation), angle, profile and representation. The spatial concepts are included in 3 (three) parts of questions. First, the participants shall be able to develop an areal referencing procedure using a coordinate system (Golledge, 2008a). They have to calculate local time using the privilege of a coordinate system. Second, the participants shall be able to develop language and means of expression of direction/orientation from a location (Golledge, 2008a). Provided with a city map and an imaginary route, the participants shall specify what building they would see in a specific location, the distance of the imaginary route and the orientation of a specific building. Last but not least, they have to be able to understand the structural properties of sets of objects in terms of land profile, angle and object shape mapping (2D and 3D). The participants will be given a map from which they have to be able to transform perceptions, representations and images from one dimension to another and the reverse (Golledge, 2002)”.
Part D	“Lastly, 3 (three) spatial concepts that are considered as simple spatial concepts are examined in the last part, e.g. class/group, boundary, scale. The spatial concepts are included in 3 (three) parts of questions. First, the participants shall comprehend the integration of geospatial features represented as points, networks, and regions (Golledge, 2002). In this part, the participants are asked to choose which representation of 3 (three) possible representation (points, networks, and area) would be fit in drawing geospatial features in a map. Second, the participants shall determine spatial limits in natural and built environments. (Golledge, 2008a). Given a contour map, the participants shall be able to indicate the number of hills or plains in an area. In order to solve this problem, they must be able to indicate the boundary of specific geospatial features. Finally, the participants shall be able to delineate surrounding objects based on their scalar and scalar relations between objects. The participants will be provided a grid map where each square in the map has specific size. The participants shall be able to calculate certain objects that can be filled in an area and the size of certain area in a map”.

Appendix II. The form used for pre-test of spatial thinking test material and feedbacks from one of the participants in the Netherlands.

Dear respondents,

This pre-test is intended to evaluate the spatial thinking test developed by Firdiansyah (2012). This test will be used latter to evaluate the spatial thinking in geographical space's ability of GIS and Non-GIS students in Indonesia. The pre-test consist of four parts in which each part has ten questions. I expect the pre-test respondents will give comments, remarks, and feedback to improve the questionnaire, e.g. the clearness of the questions, the quality of the pictures, the length of each question, etc. Please write down your answer and comments in the available form.

Thank you

Table 18. An example of the answer and feedbacks in the pre-test of spatial thinking test material in the Netherlands.

No.	Answer	Question's clearness (Write down 1 or 2) **1** = **not clear**, need improvement **2**= **clear**, no need for any improvements	Comment and/or feedback
PART B			
1.	B	2	
2.	B	2	Most green numbers are hard to read, crisp them a little bit.
3.	D	2	I didn't know that you'd call wine a spatial primitive
4.	C	2	
5.	C	2	
6.	B	2	Not so famous after all. The question is clear, what is not clear is Minard's chart. The reason I chose B is because it is the latest date and I suppose that a chart that shows the march should start when the march starts and should end when the march ends.

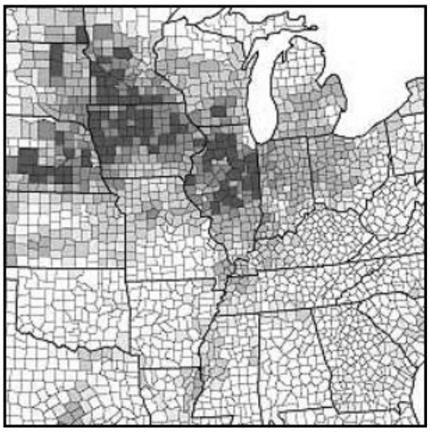
No.	Answer	Question's clearness (Write down 1 or 2) **1** = **not clear**, need improvement **2**= **clear**, no need for any improvements	Comment and/or feedback
7.	D	1	Why do you use AD for 2100, it's less than 100 years ahead, just say 2100, people would assume that if you would have wanted to say BC, you would have written BC.
8.	C	1	2100AD. I have no clue what sycamore is. It didn't matter for the first question, but apparently it has something to do with the habitat of something
9.	B	2	
10.	A	1	May be given for what? Let's say that someone asks "what is your latitude?", then it doesn't matter if I'm in ABCD or E, I may give him no longitude and he would be satisfied. I think this question can be rephrased something like: In which area longitude is hard/impossible to determine?

Appendix III. The evaluated spatial thinking test material used for GIS and non-GIS students in Indonesia.

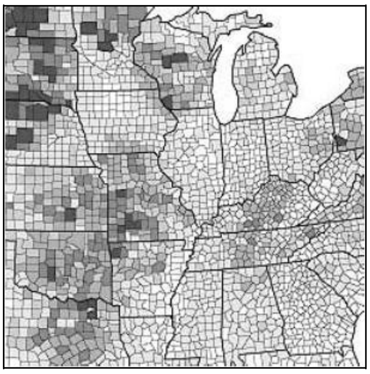
PART A

PART A

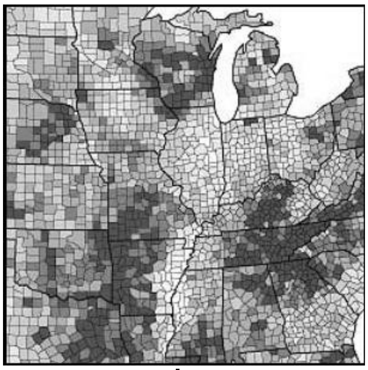
1. Of the following maps (A-E), which map has a strong positive correlation (similar pattern) with the map X below (AAG, 2005)?



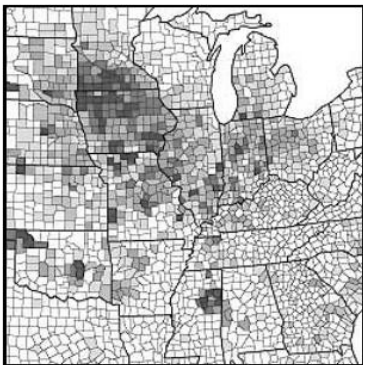
Map X



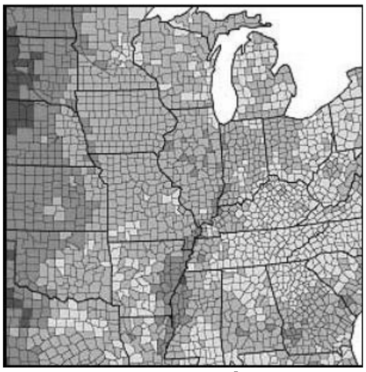
a



b



c

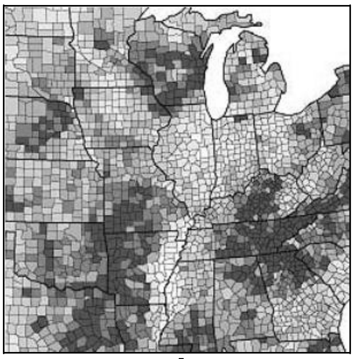


d

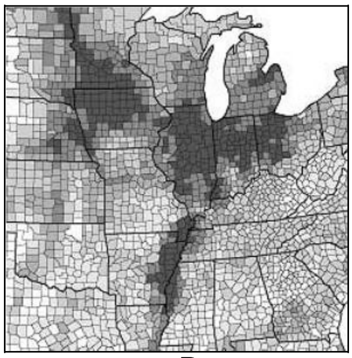
e

PART A

2. The next two maps (AAG, 2005) are map of (A) acres of corn production and (B) value of hogs and pigs as percent of total market value of agricultural products sold.

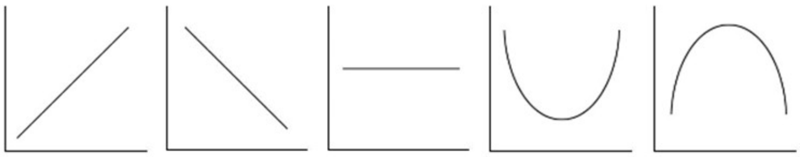


A



B

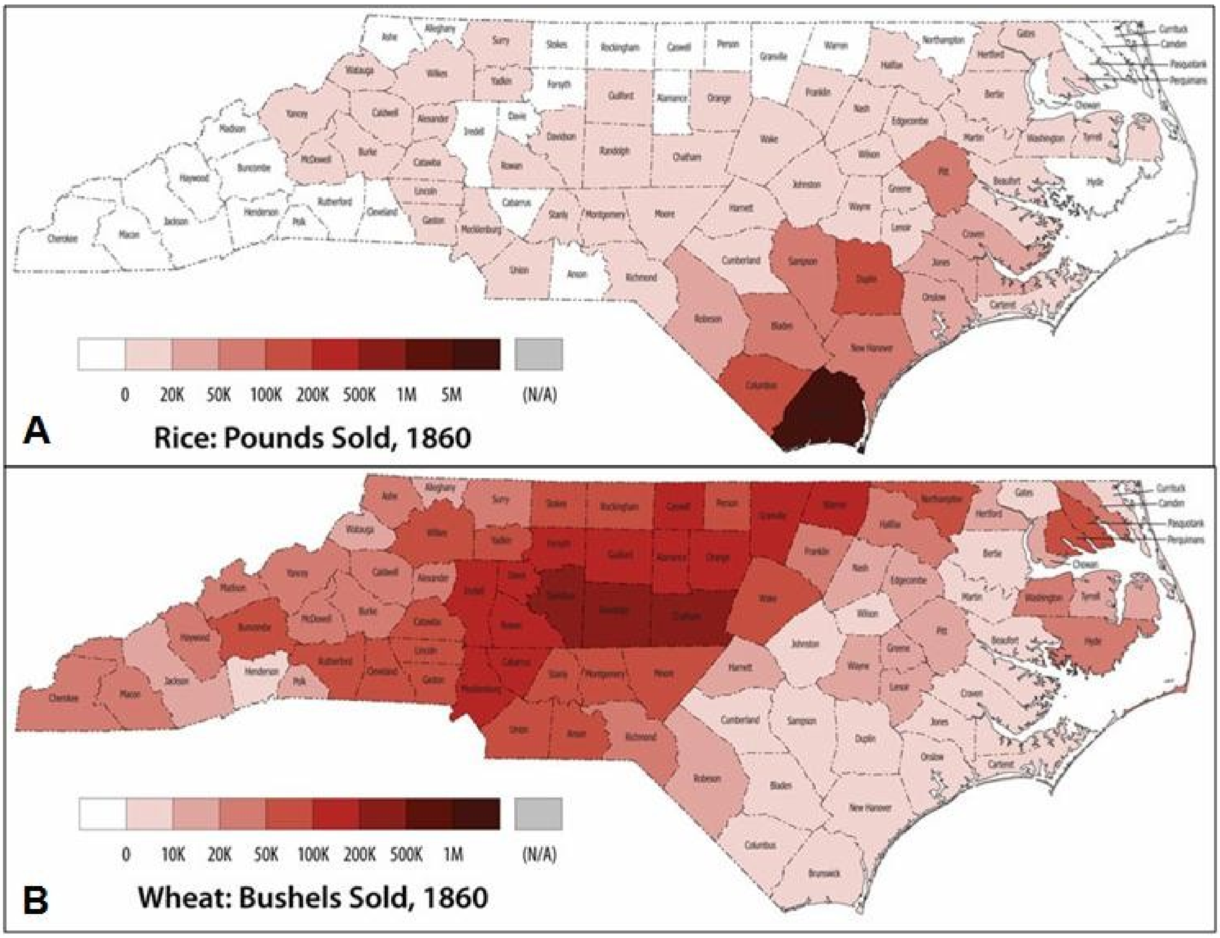
Which graph may represent the relationship between map A and B?



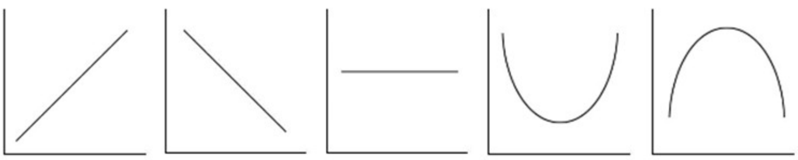
a b c d

PART A

3. The following two maps indicate the amount of wheat and rice sold in North California in 1860 (www.learnnc.org).

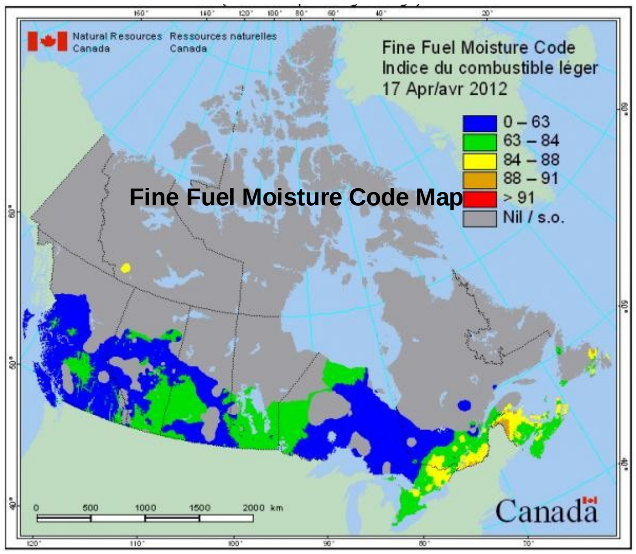


Which graph may represent the relationship between map A and B?

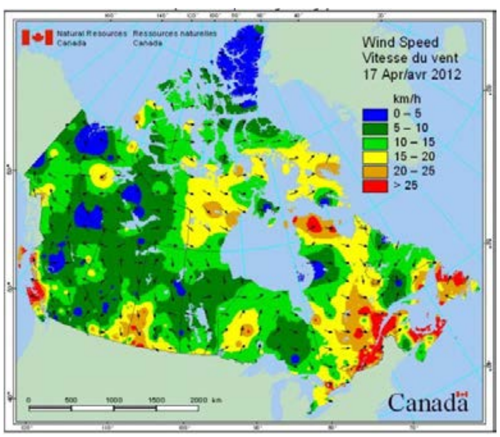


a b c d

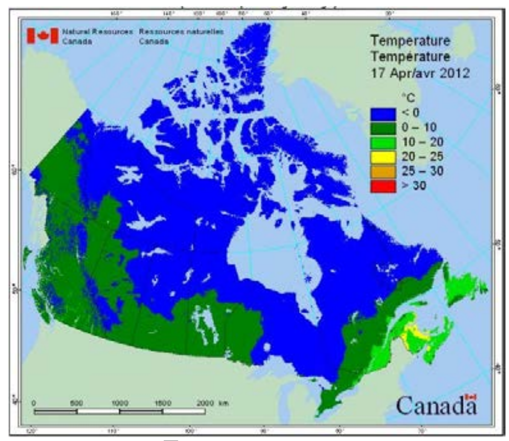
PART A



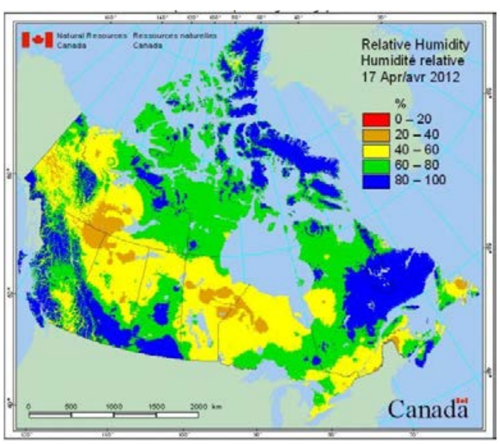
4. Above is a map of Fine Fuel Moisture Code (FFMC) on 17 April 2012. The grey area in the map indicates that the data/calculation is **not available** so you may ignore it. This code is an indicator of the relative ease of ignition and the flammability of fine fuel. The higher the number of the code, the higher of the possibility of fire spread. According to CWFIS, there are 4 (four) factors that influence FFMC, such as temperature, relative humidity, wind and rain. Below are maps of wind, temperature, relative humidity and rain on the same date (17 April 2012).



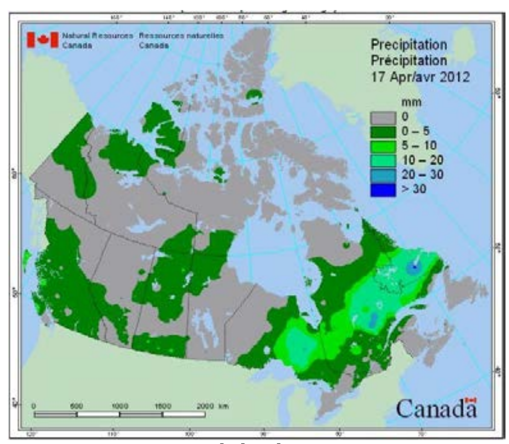
Wind speed



Temperature



Relative humidity

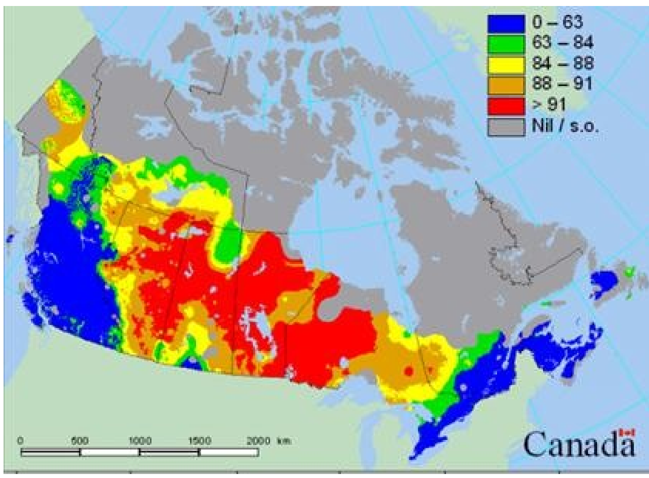


Precipitation

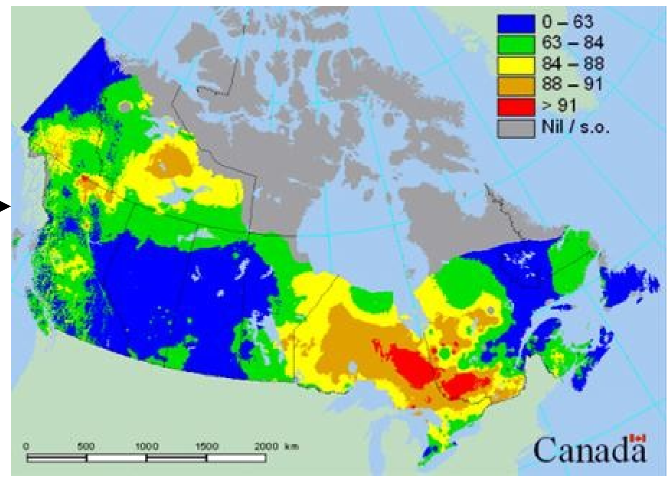
Which factor(s) has (have) reverse pattern/trend with the pattern of FFMC?

a) Wind speed and temperature
b) Temperature
c) Relative humidity and precipitation
d) Relative humidity
e) Precipitation

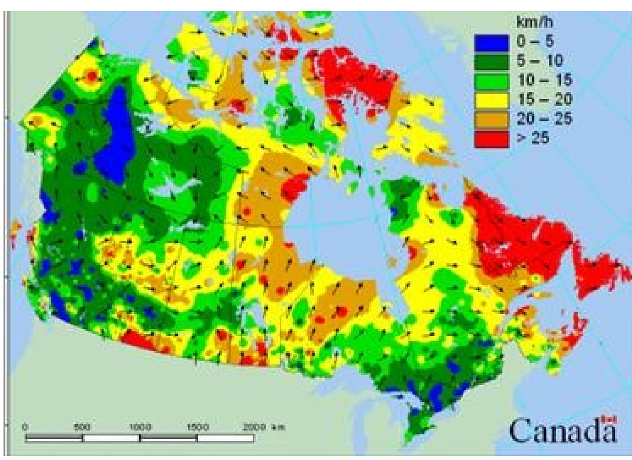
5. Suppose that FFMC has similar pattern with wind speed and you have maps of FFMC growth as depicted below (picture X and Y, picture X is the first sequence). Which map would you expect to be the sequence of the wind speed map below (picture Z)? (Hint : take a close look at the part at lower half of the maps Z, a, b, c, d and e)



X



Y

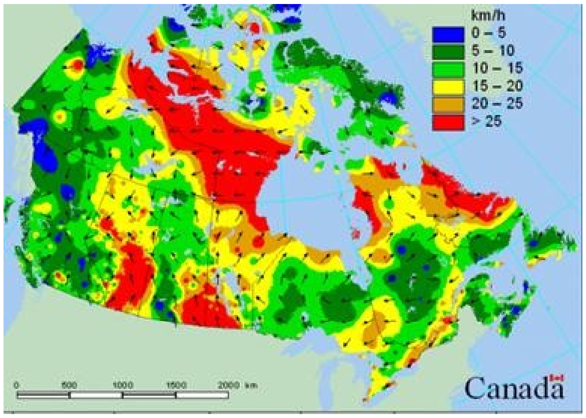


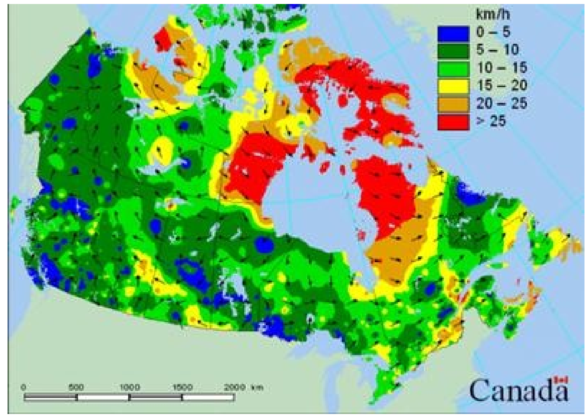
Z

?

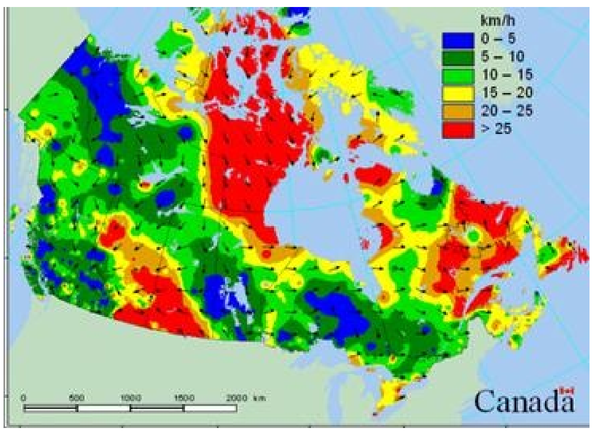
PART A

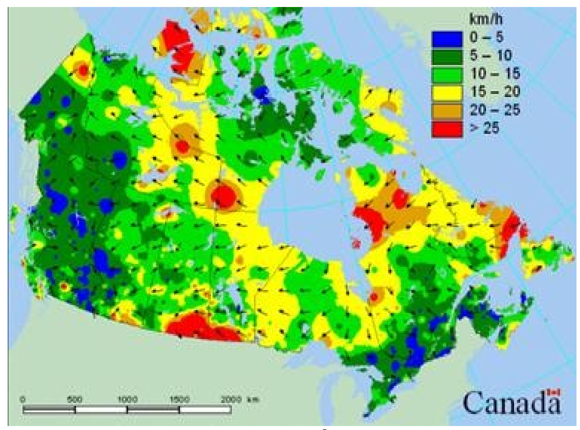
Which is the sequence of map Z above?



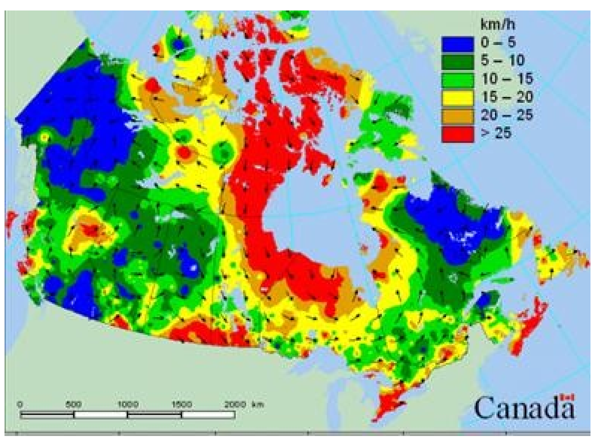


a **b**





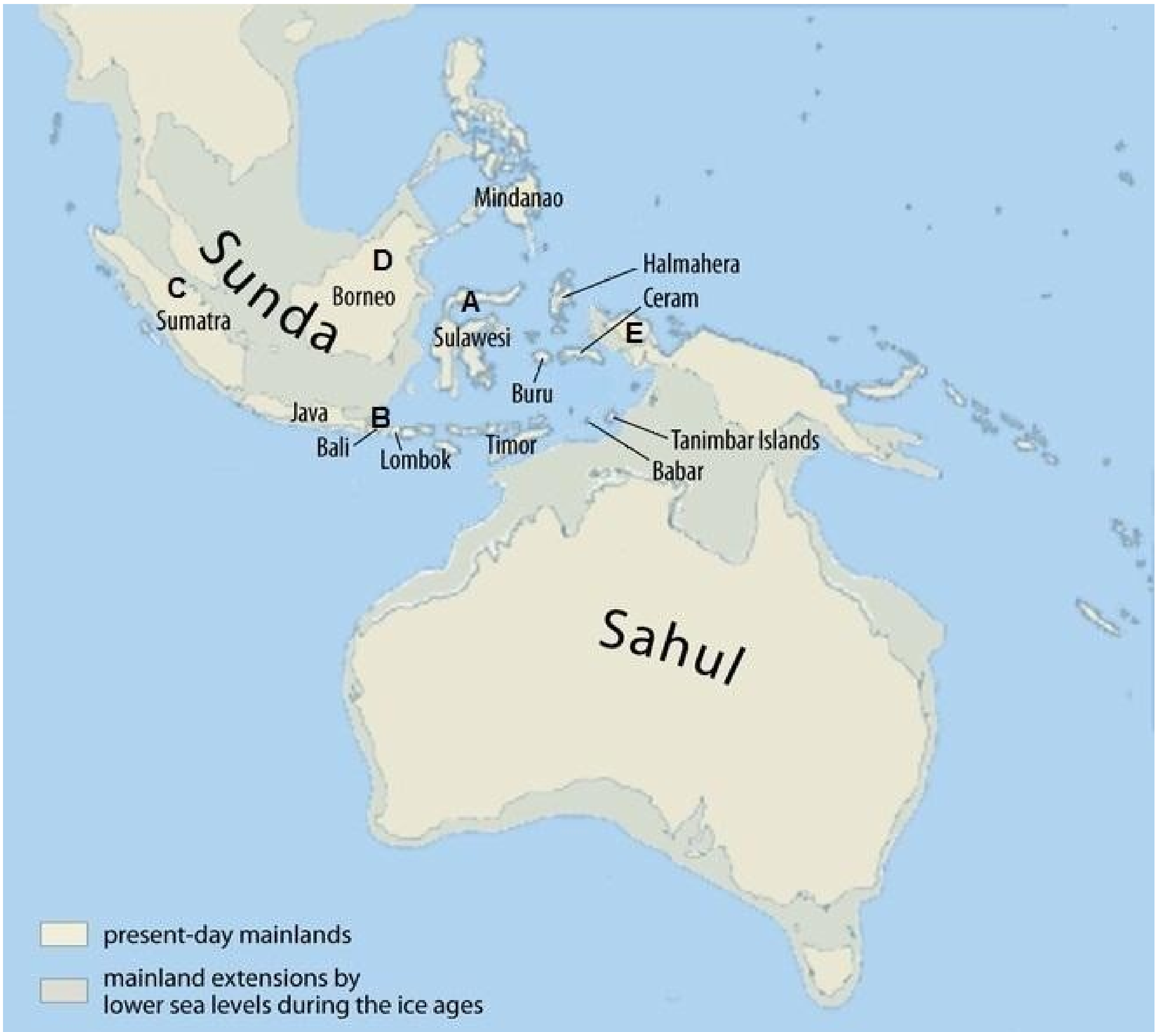
c **d**



e

PART A

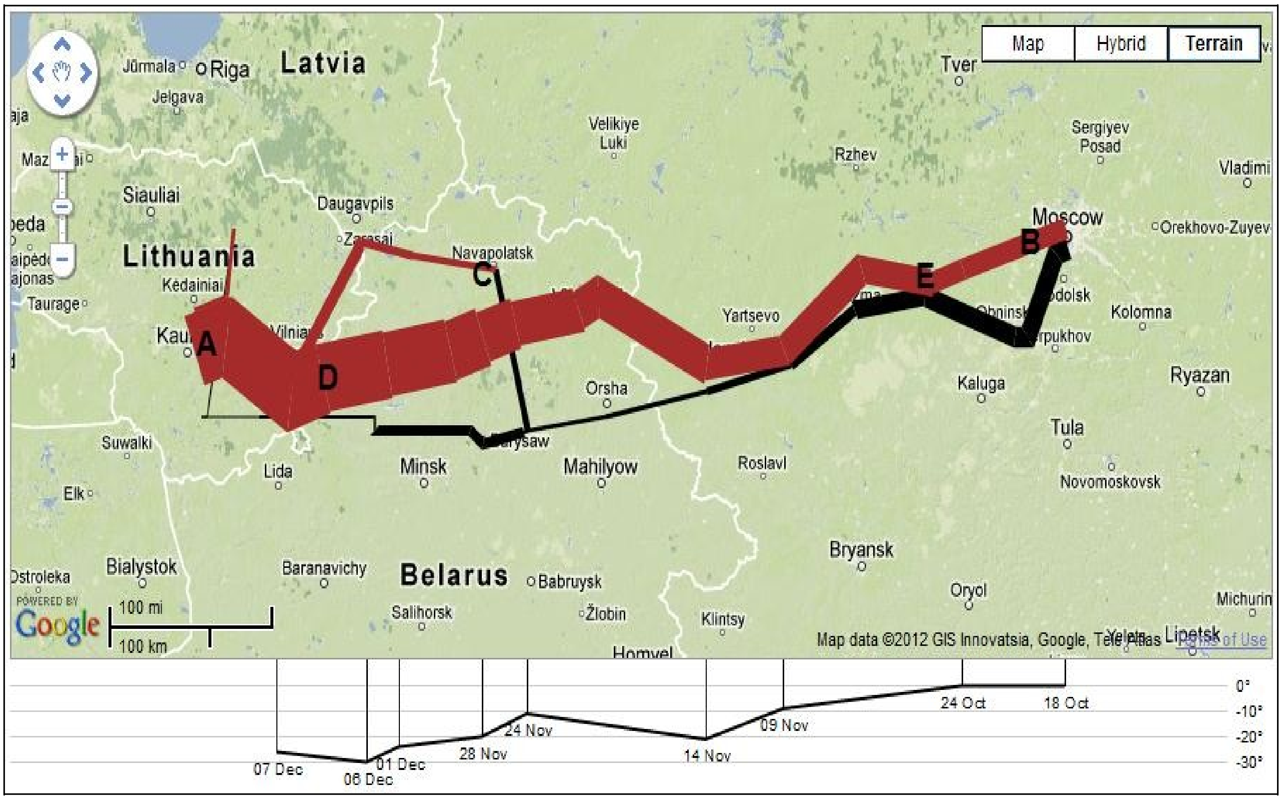
6. In which area depicted in following map you might find more extensive original fauna?



a) A (Sulawesi)
b) B (Bali)
c) C (Sumatra)
d) D (Borneo/Kalimantan)
e) E (Papua)

PART A

7. In 1812, Napoleon tried to occupy Russia by sending a great campaign followed by approximately 422,000 men. A new work at Stanford University has used a mashup of Google Maps and a visualization tool to produce a digital presentation of Minard's chart as you can see below.



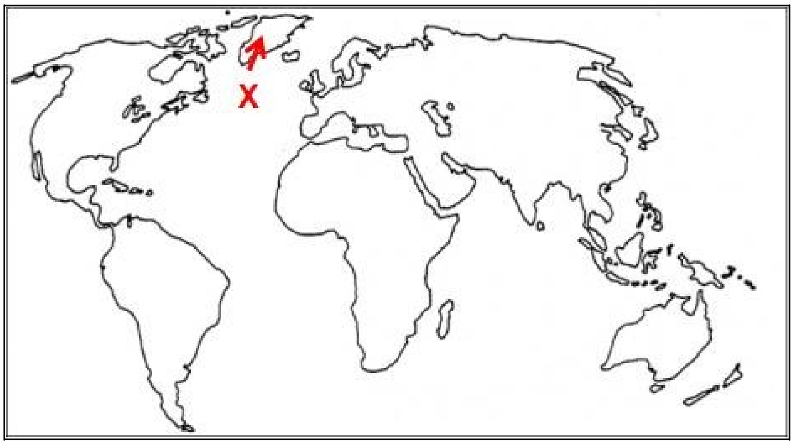
Red line : the lane of Napoleon armies towards Russia
Black line : the retreat of Napoleon armies lane from Russia

Napoleon ordered his army to cover the supply lines and any possible retreat during his march meaning that he wanted to prevent his army from starvation and desertion. According to the map above, in which area/city might this order be conducted?

a) A
b) B
c) C
d) D
e) E

PART A

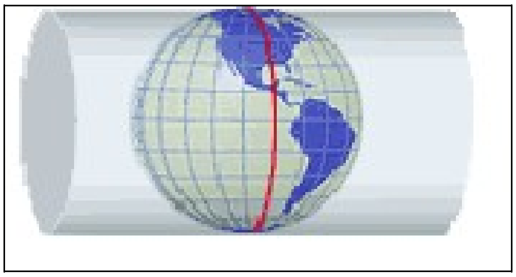
8. Map projection is a representation of the surface of the world/globe onto a flat 2D map. A map is 2D representation of a 3D world where accuracy needs to be compromised. Suppose you administer a country in a north hemisphere of the world, depicted by **X** in the picture below, and want to influence your people that your country has a large territory to encourage them during the wartime which map projection would you choose to be used in your country?



a) Mercator projection

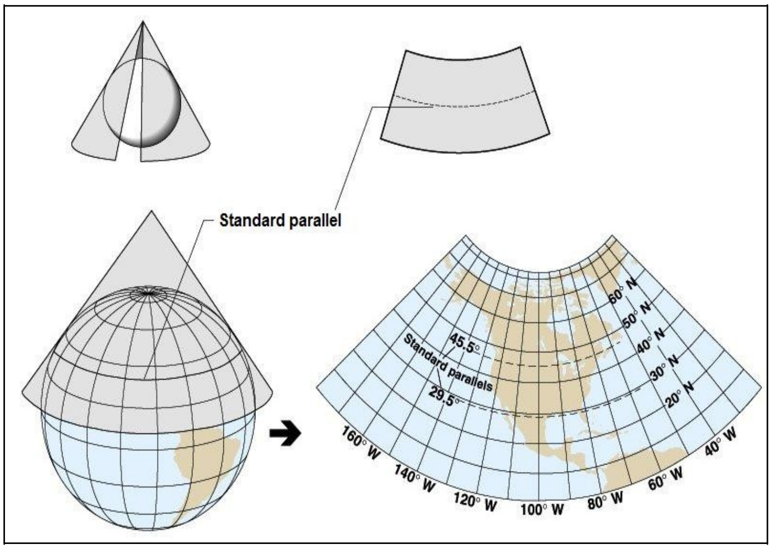
For the Mercator projection, the axis of the cylinder lies in the equatorial plane, and the line of tangency is any chosen meridian, thereby designated the central meridian.

b) Transverse Mercator projection



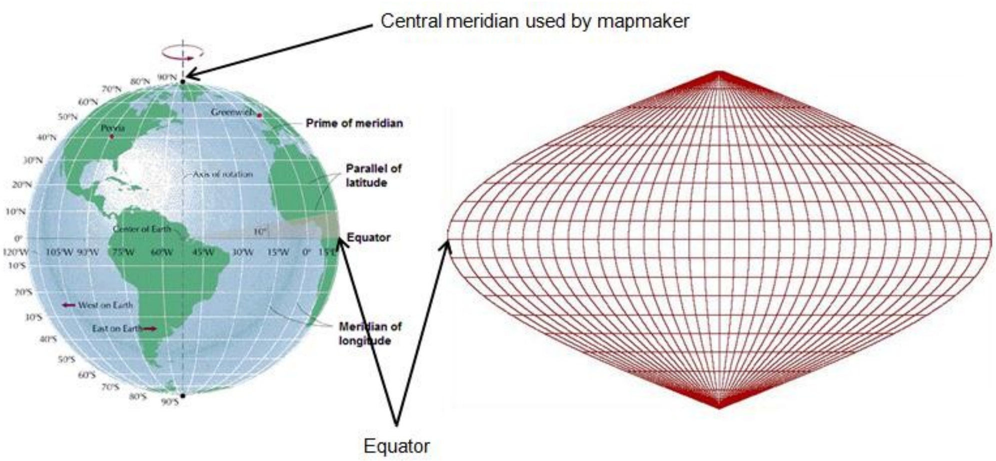
Transverse Mercator projection is also a type of cylindrical projection map. However, the axis of the cylinder coincides with the polar axis and the line of tangency with the equator.

c) Albers projection



Albers projection does not preserve scale and shape, but the distortion between the standard parallels (imaginary lines that are parallel to the equator).

d) Sinusoidal projection



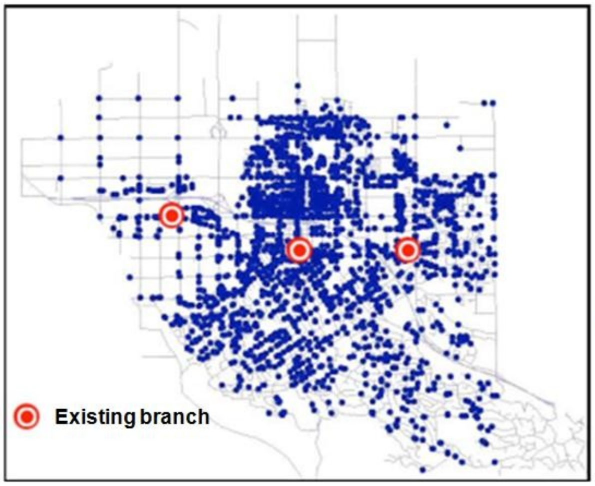
The globe is drawn and projected in the 2D sinusoidal plane using equator and prime meridian as the references

Sinusoidal projection is a type of pseudocylindrical projection which represents the central meridian and each parallel (imaginary lines that are parallel to the equator) as a single straight line segment, but not the other meridians (imaginary lines that cross from North to South which converge in the North/South Pole).

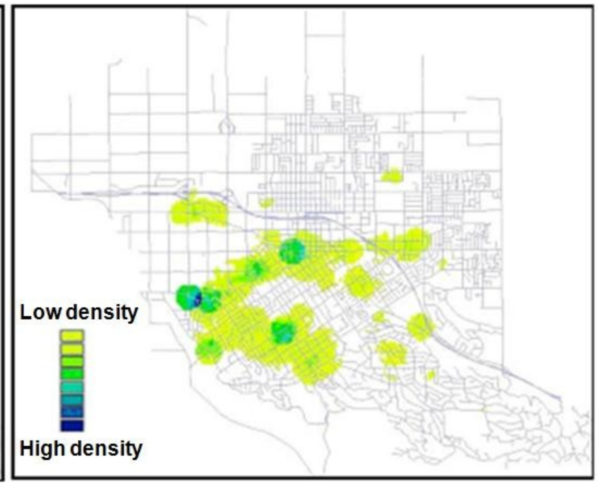
e) None of them is true

PART A

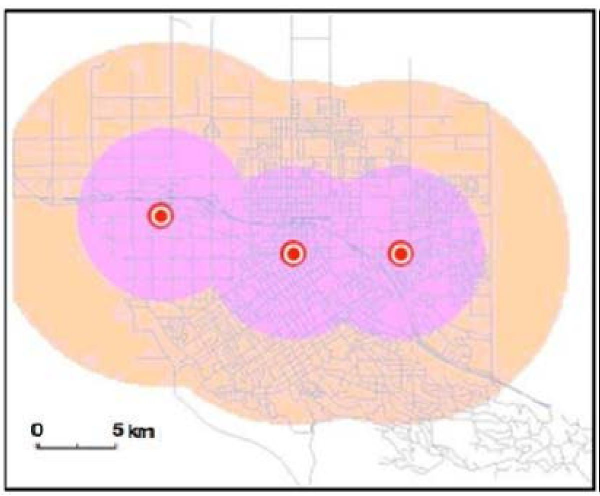
9. A new restaurant is going to be built. Since this is a branch of a big restaurant, it is expected that the new restaurant is built more than 5 km from existing branch. The main company does not want each branch to compete each other. The new restaurant should also be accessible for the customers. The main company expects the new restaurant is built within an area in which the loyal customers live (AAG, 2005).



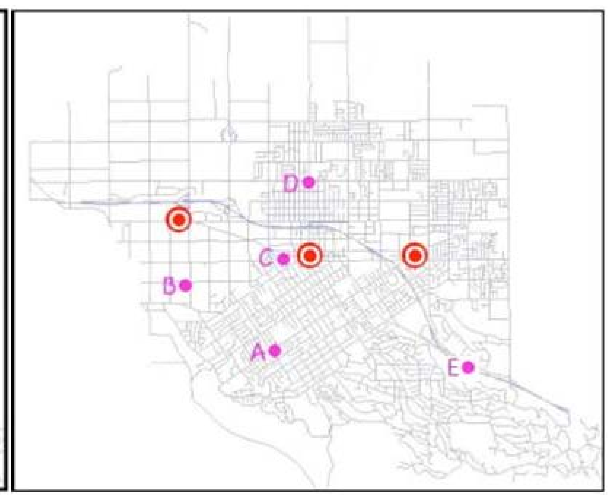
Population distribution



Customer density



Distance from existing branch



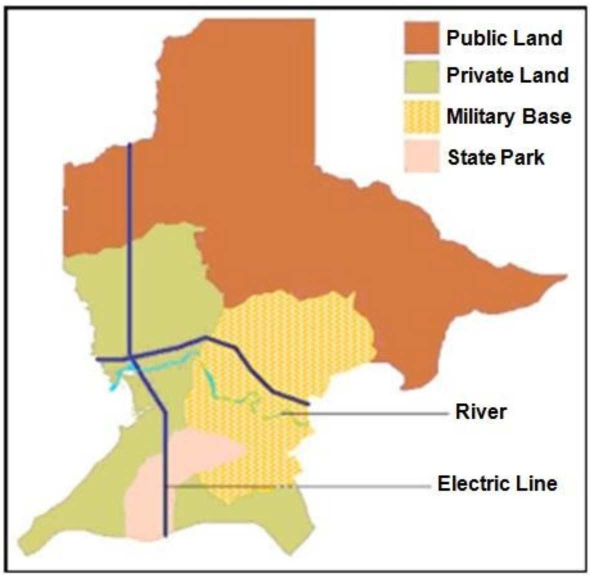
Potential branch location

Where is the best location for the new restaurant in the map of **potential branch location** above?

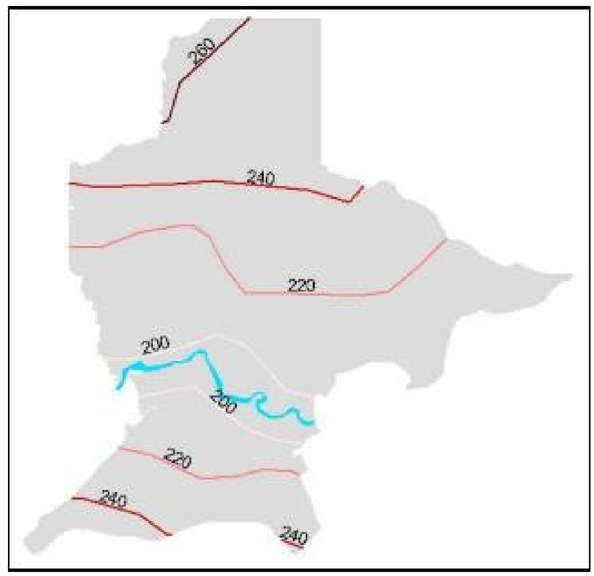
a) A
b) B
c) C
d) D
e) E

PART A

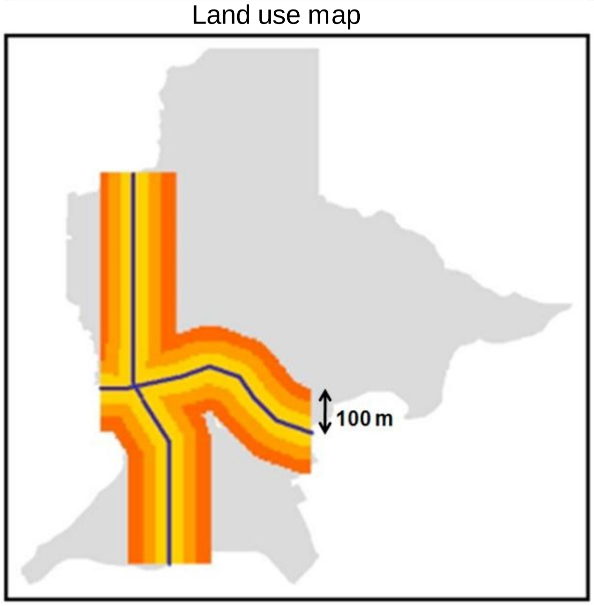
10. The government is going to build a planetarium with several requirements. First, the planetarium should be located in a place more than 240 elevation level. Second, the planetarium should be built within 100 m of an existing electric line. Lastly, the government wants to build the planetarium in State Park or Public Land to reduce land acquisition cost. Below are the required maps that have been gathered (AAG, 2005).



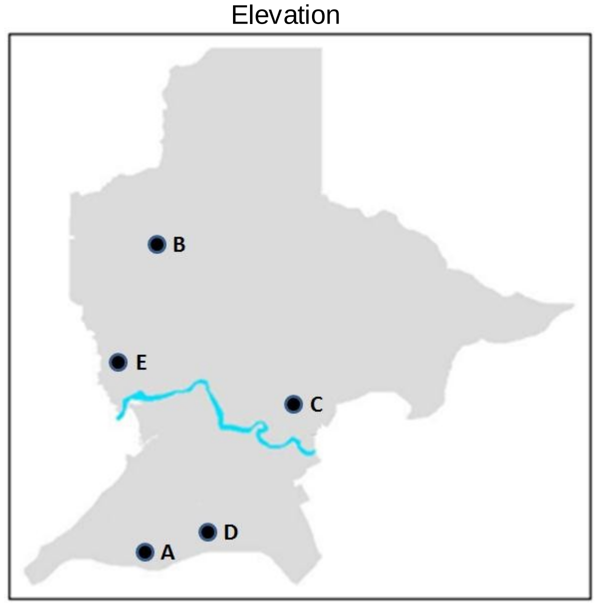
Land use map



Elevation



Electric line



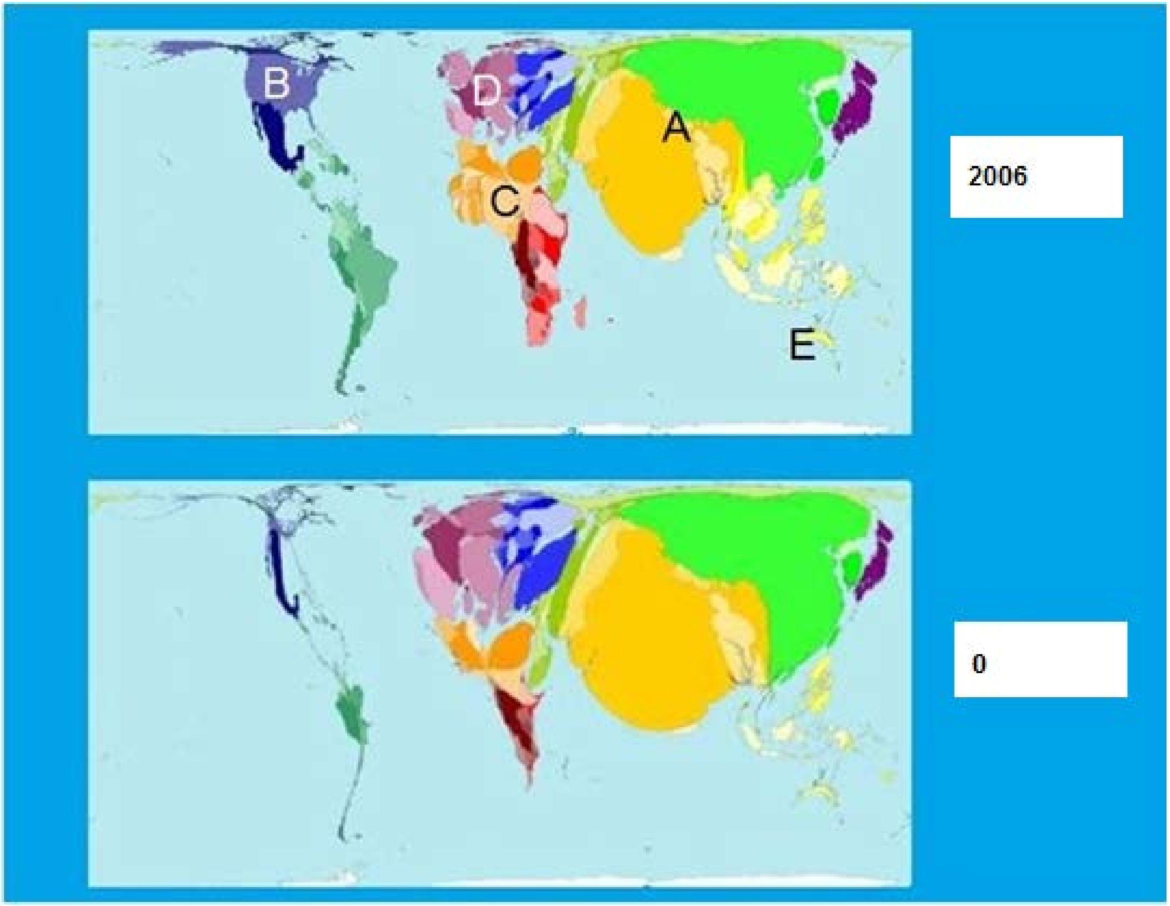
Potential location

Where is the best location for the planetarium in the map of **potential location** above?

a) A b) B c) C d) D e) E

PART B

PART B



1. In which area is the most likely a high number of immigration happened between the periods of 0 to 2006 based on the picture above (www.worldmapper.org)?

   a) A
   b) B
   c) C
   d) D
   e) E

PART B

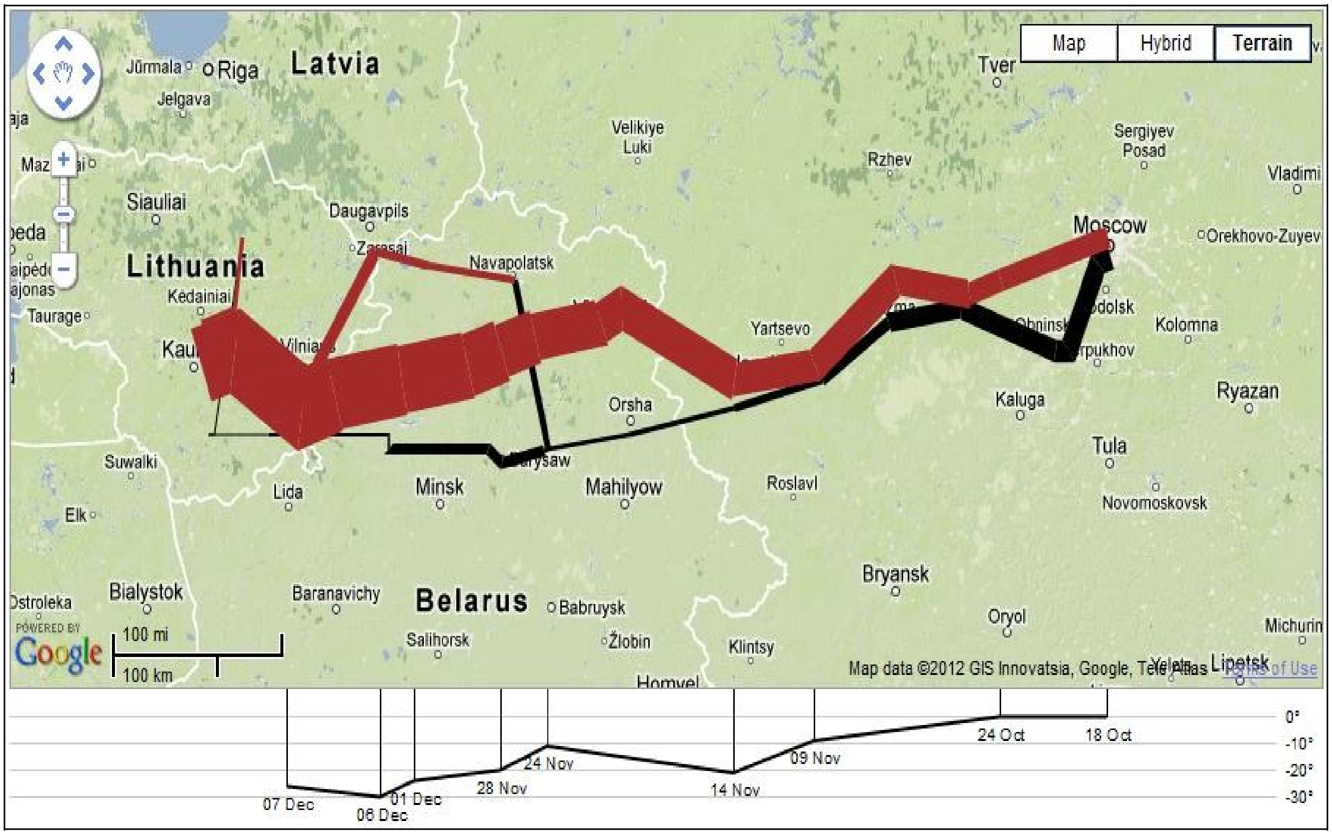
2. According to the map above (www.doctorsoftheworld.org), what do you think about the number of doctor in South East Asia (area within the red circle) relatively compared to other areas?
    a) Very Low
    b) Low
    c) Average
    d) High
    e) Very High

3. You are about to draw a map of winery maintenance system. According to you, which of these spatial primitives is not appropriate to be included in the map?
    a) Wine
    b) Building
    c) Road
    d) People
    e) Hedges

4. Which of these instances needs additional information if it is used to locate a place?
    a) ZIP Code
    b) Street and city names
    c) Compass
    d) Landmark
    e) GPS

PART B

5. Which dataset or feature can be excluded when mapping crop growth in relatively narrow area?
   a) Soil feature
   b) Water bodies
   c) Climate
   d) Land use
   e) Crop characteristic

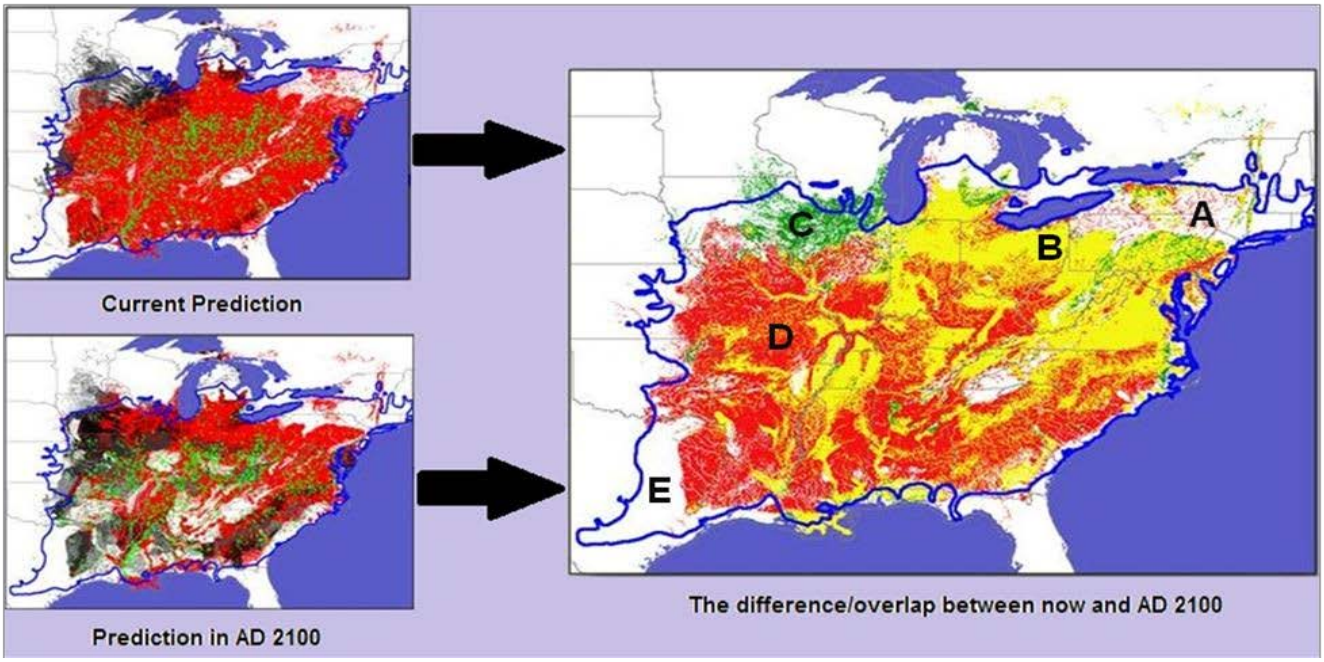


Red line : the lane of Napoleon armies towards Russia
Black line : the retreat of Napoleon armies lane from Russia

6. Above is a mash up map of the famous Minard's chart depicting the disastrous march of Napoleon to Moscow in 1812 created by Stanford University. According to the picture, when did Napoleon ask his troops to retreat?
   a) 28 November 1812
   b) 7 December 1812
   c) 9 November 1812
   d) 24 October 1812
   e) 18 October 1812

PART B

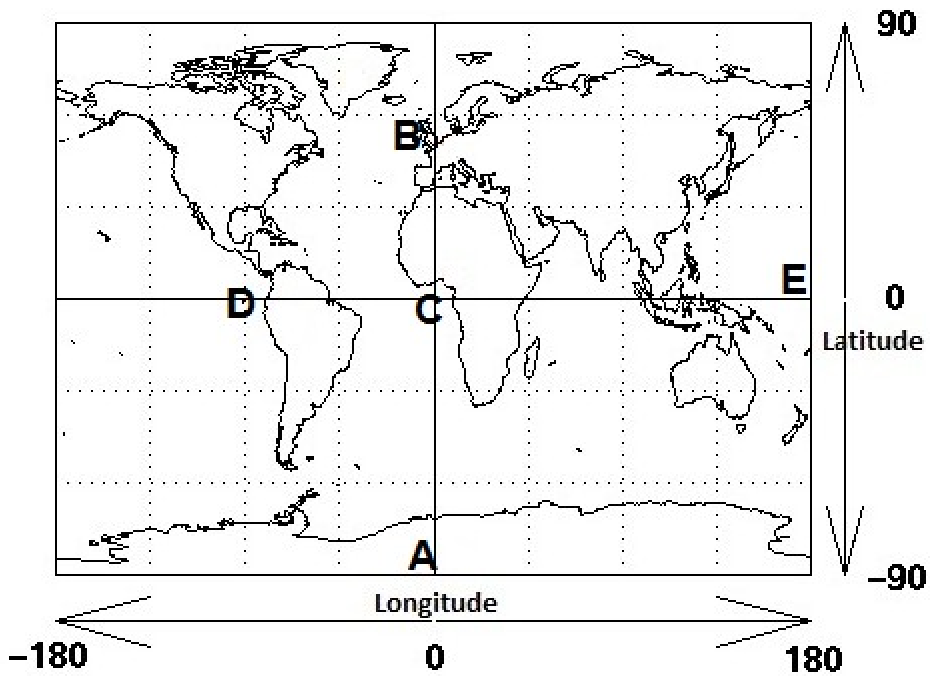
The picture below is a map of sycamore distribution currently and in AD 2100. In the **left pictures** (upper left and bottom left), the **green** colored areas are areas where the **sycamores are gone** and the **red** colored areas are areas where the **sycamores exist**. The right picture below on other hand is the prediction map delineating the difference/overlap of the sycamore existence between now and AD 2100. The right picture uses an overlay operation of two maps in the left. You must also note that ***the right picture does not use the same color as the left picture below in depicting the legend of area where sycamores exist***.



7. In which area depicted in the right map the sycamores may be gone in AD 2100?
   a) A
   b) B
   c) C
   d) D
   e) E

8. According to the prediction map of AD 2100 (right map) new habitats are also found in some areas. In which area depicted in the right map the new habitat may be found in AD 2100?
   a) A
   b) B
   c) C
   d) D
   e) E

PART B



Answer the questions number **9 and 10** based on the picture of latitude-longitude above.

Lines of longitude (meridians) running north-south around the globe measuring the distances East (indicating by (+) sign) and West indicating by (-) sign) of the Prime Meridian (0° of Longitude). Lines of latitude are imaginary lines appearing horizontal running east-west and used to measure distances North (indicating by (+) sign) and South (indicating by (-) sign) of the equator.

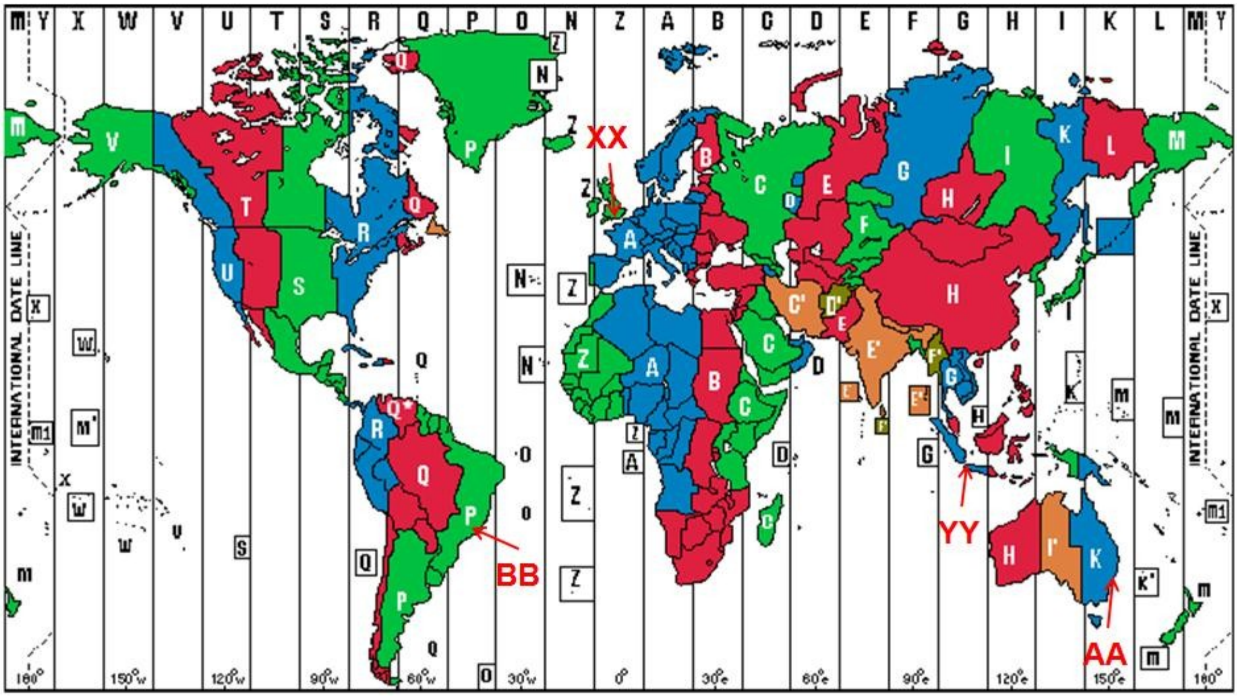
9. How many pair of values in latitude-longitude coordinate system at least that can be used to calculate the distance between two objects?
   a) 1
   b) 2
   c) 3
   d) 4
   e) 5

10. Based on the picture above, in which area no longitude may be given? (The area is shown by letters within the picture)
    a) A
    b) B
    c) C
    d) D
    e) E

PART C

Part C

1. The time in a certain time zone is an hour earlier than the zone east of it and an hour quicker than the zone west of it.



In the picture above you can see a sequence of letter representing 24 time zones around the world. The 0° of longitude is referred to prime meridian at which passes from the North Pole to the south across Greenwich, London, Gulf of Guinea and other places until the South Pole. Originally, you can calculate the time difference between two places by counting the difference between the mean of longitude values of two places, indicated by a sequence number of degrees in bottom of the picture above, which is then divided by 15.

You are travelling from Jakarta (YY) on Monday at 04.45 of local time westwards to London (XX) which takes about 18 hours and 35 minutes. Disregarding DST, what date and time will you arrive at London?

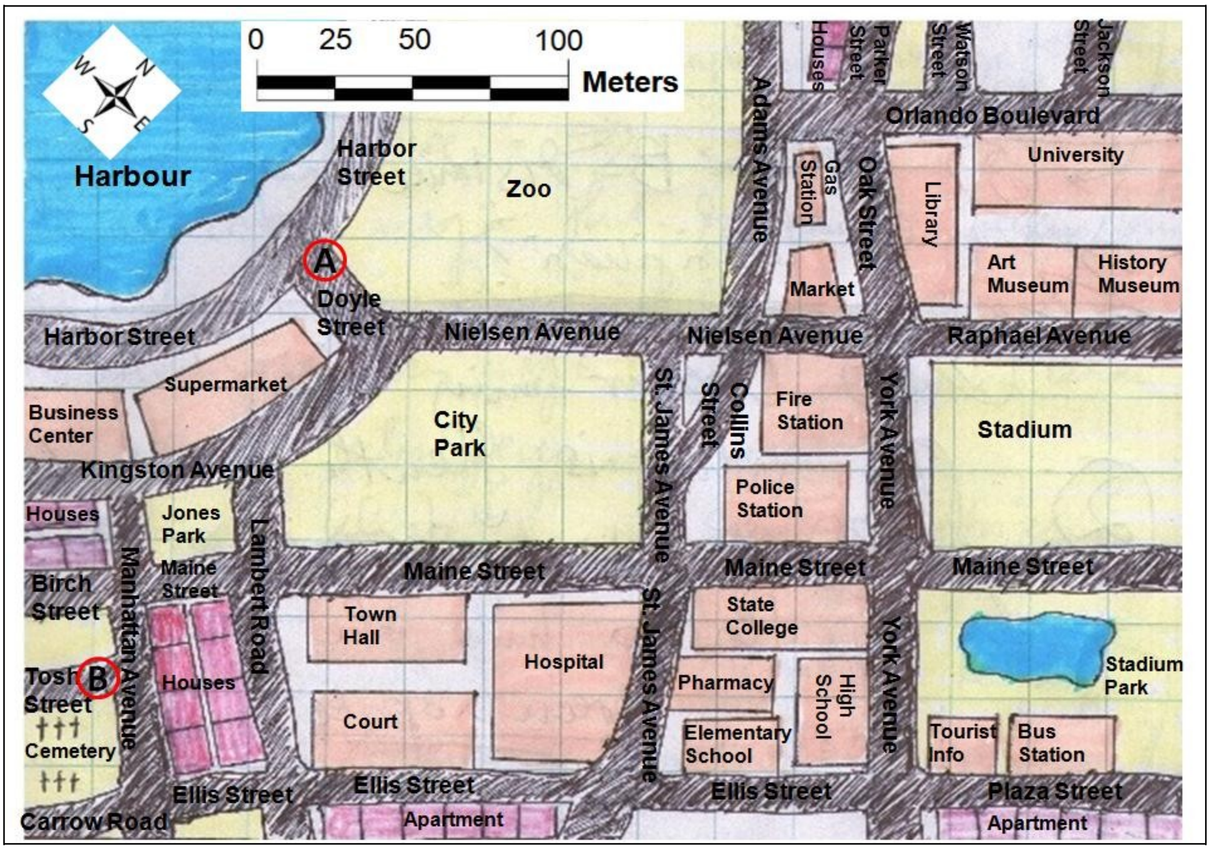
a) Tuesday at 16.20
b) Monday at 23.20
c) Tuesday at 01.20
d) Monday at 06.20
e) Monday at 16.20

2. Suppose you are going eastwards from Sydney (AA) to Rio de Janeiro (BB). You leave Sydney at 10.45 of local time and arrive in Rio de Janeiro at 16.30 of local time on the same day when you leave Sydney. How long does the journey take time?

a) 5 hours and 45 minutes
b) 18 hours and 45 minutes
c) 12 hours and 45 minutes
d) 18 hours and 15 minutes
e) 6 hours and 15 minutes

PART C

Examine a map of city below to answer question number **3 to 5**.



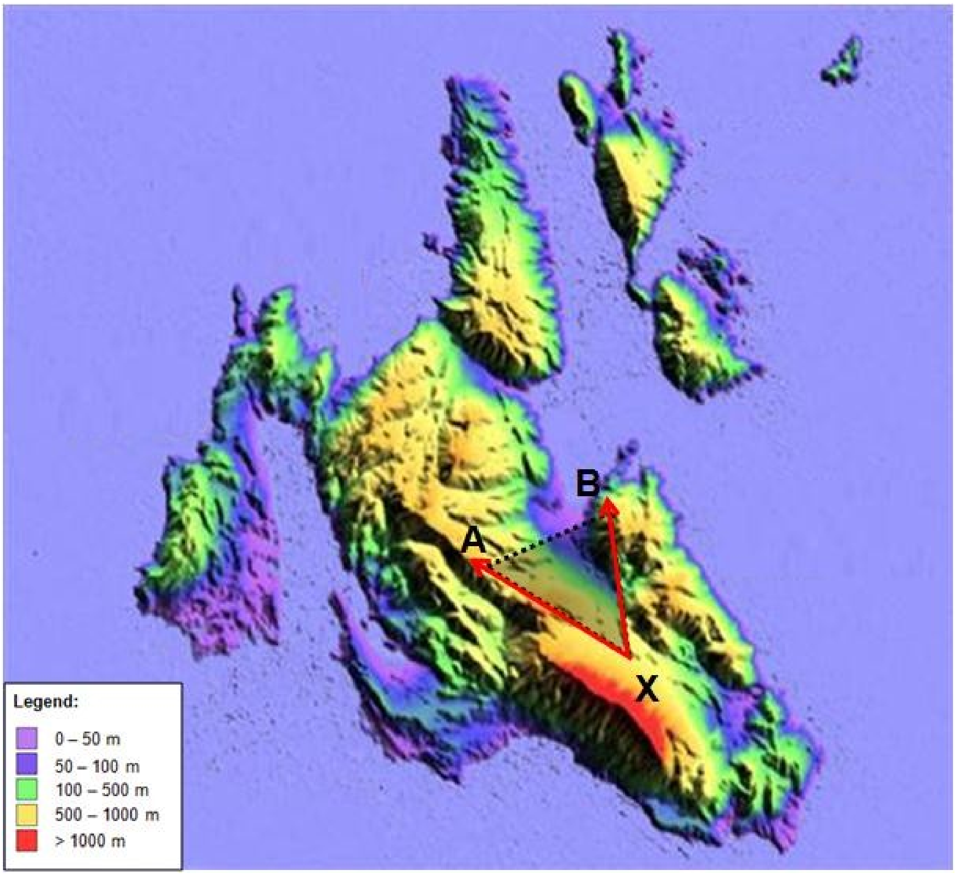
3. If you cross Doyle Street (shown by letter **A**), turn left at Nielsen Avenue, go forward and turn right at the first junction you meet, move forward and turn left at the first crossroads, what building would you see on your left?
a) Stadium
b) Town Hall
c) Police Station
d) State College
e) Tourist Info

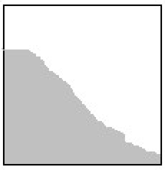
4. Consider you are standing on the middle of the building which is the end point after you walked from Doyle Street according to the direction mentioned by the previous question, how long have you been walking?
a) 300 meters
b) 200 meters
c) 225 meters
d) 325 meters
e) 250 meters

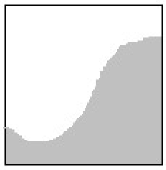
5. If you walk across Tosh Street (letter **B**) near the cemetery, turn right and then turn left at the first junction, cross two crossroads, to what side of the second building would you be standing? (The arrows depicted inside the buildings sign the direction where the buildings face towards)
a) North East
b) South East
c) North
d) South West
e) North West

PART C

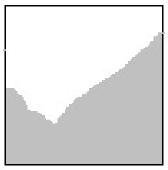
6. If you are standing on X and looking in the direction of A to B, which elevation profile below may delineate what you have seen?

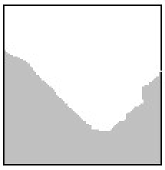



A


B

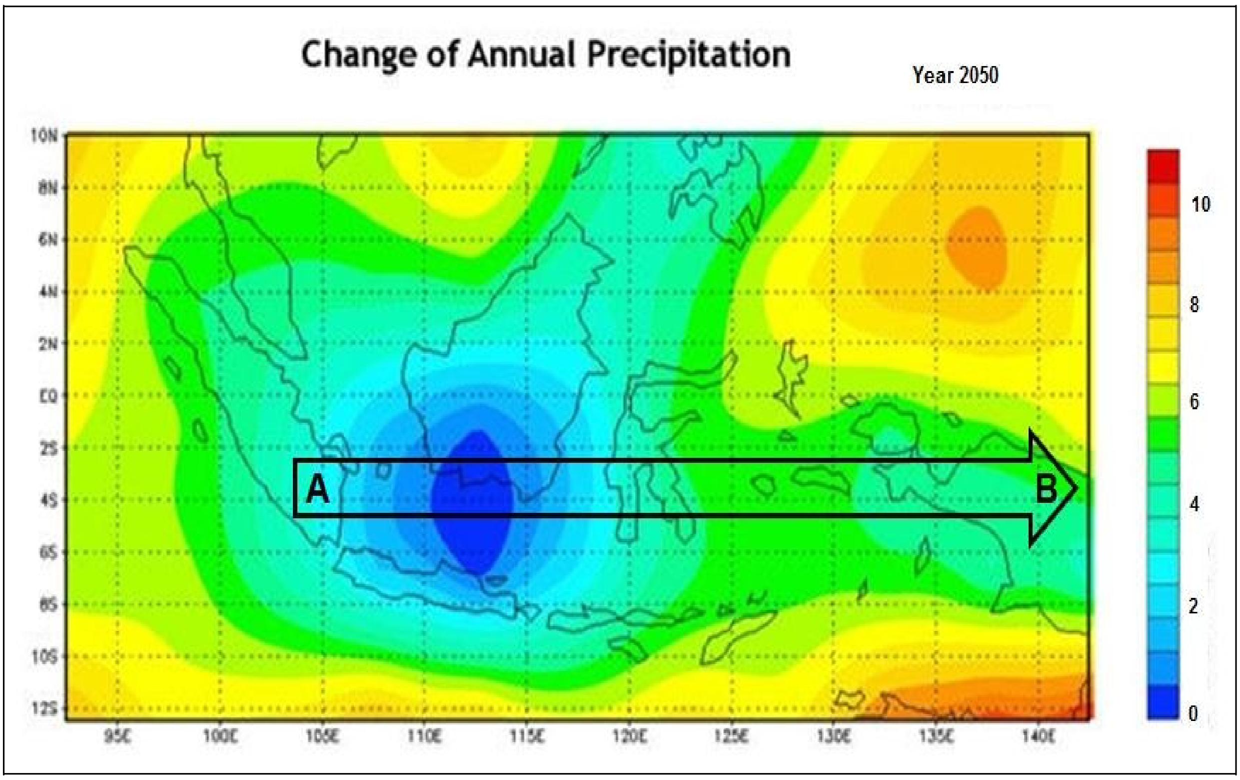

C

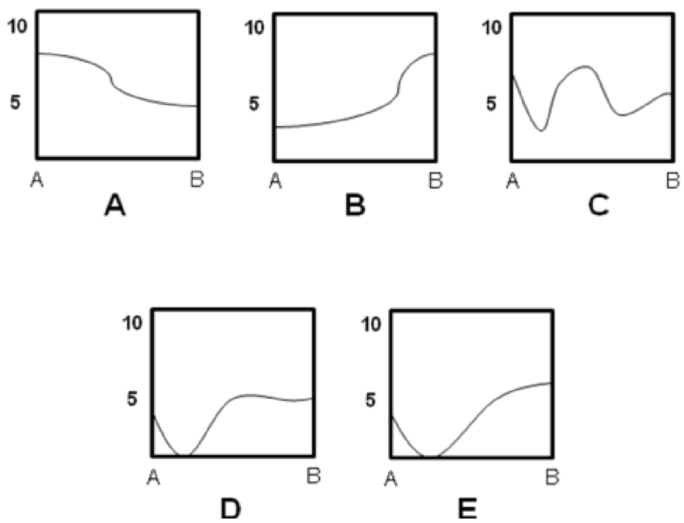

D


E

PART C

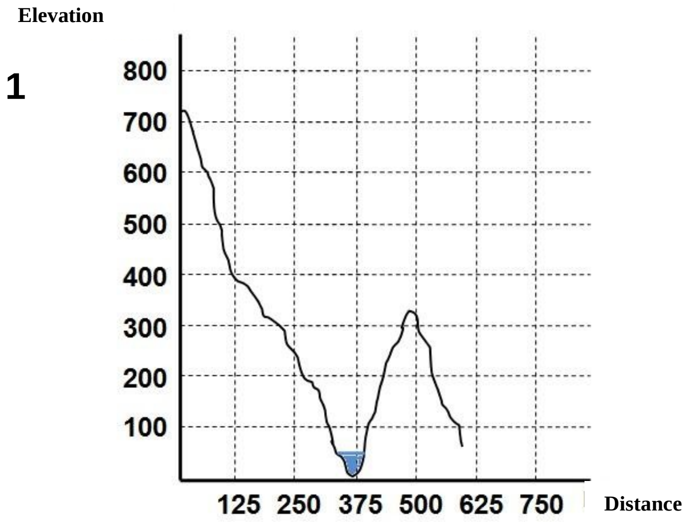
7. Below is a map of change of annual precipitation. Which is the suitable graph that may represent the change of annual precipitation of the area within the arrow between A and B?



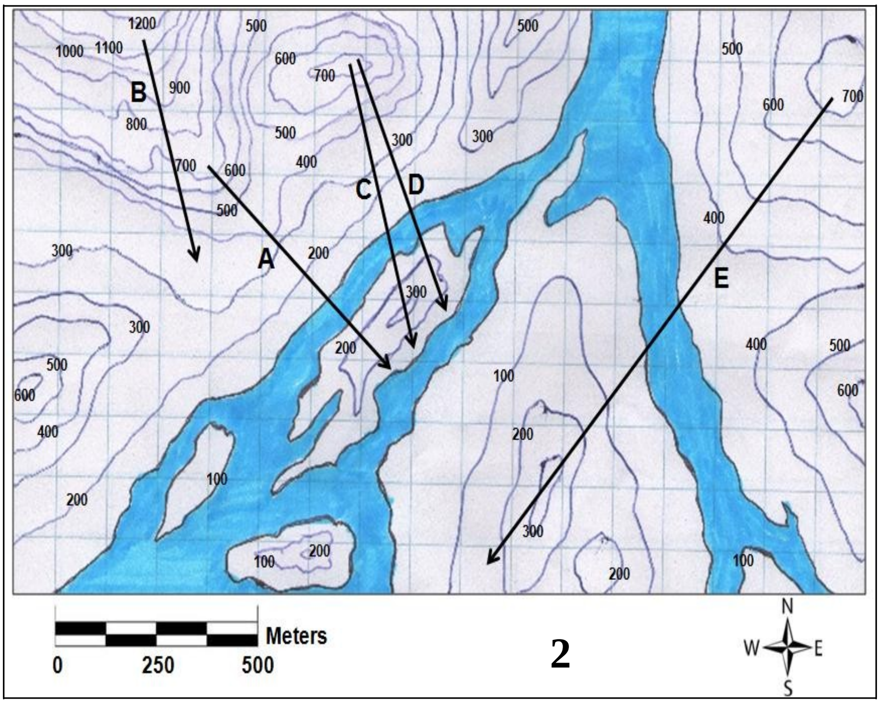


PART C

Please answer the questions number **8** and **9** based on the 2 (two) following picture below. Below



Picture 1 is the picture of certain area elevation. The horizontal axis shows the distance between elevations, while the vertical axis depicts the height. The water body is represented by blue colored area between the peaks.



Picture 2 at the left side shows the contour lines in a certain area. The contour lines connect the points with same elevation.

8. If the height of the water body is 50 meter mean sea level, which arrow (A, B, C, D, E) at the picture 2 that shows the contour line at picture 1?

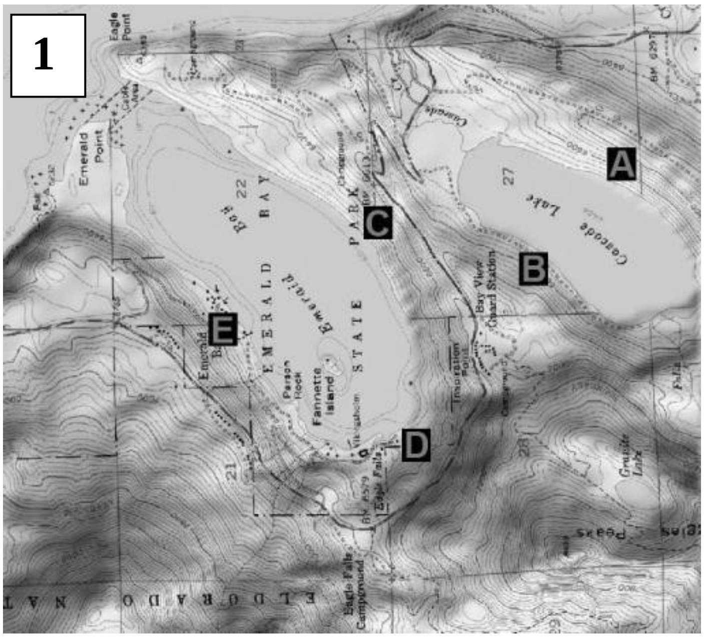
a) A b) B c) C d) D e) E

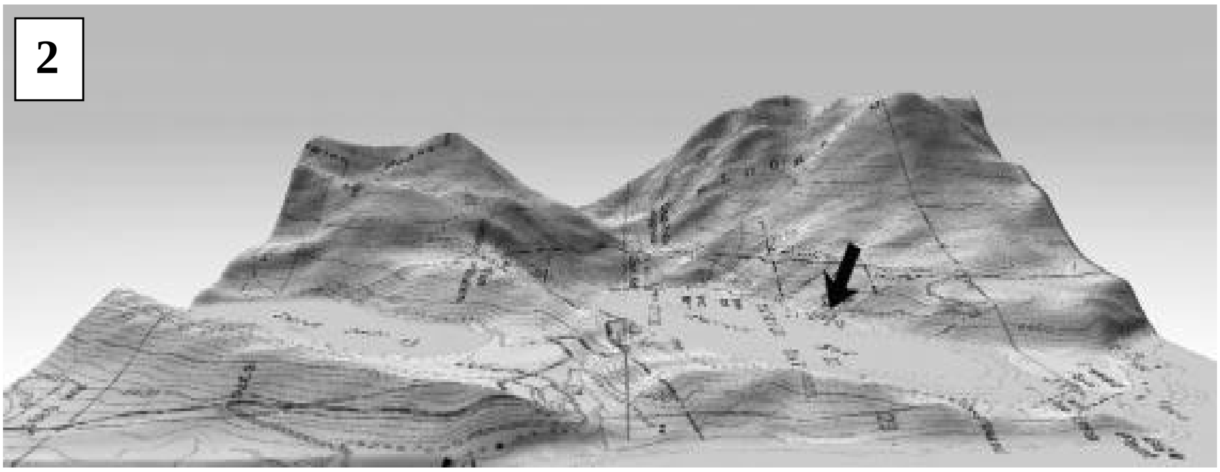
9. Which direction (arrow) at picture 2 has steeper slopes?

a) A b) B c) C d) D e) E

PART C

10. The following 2 (two) images delineate the same area (AAG, 2005).



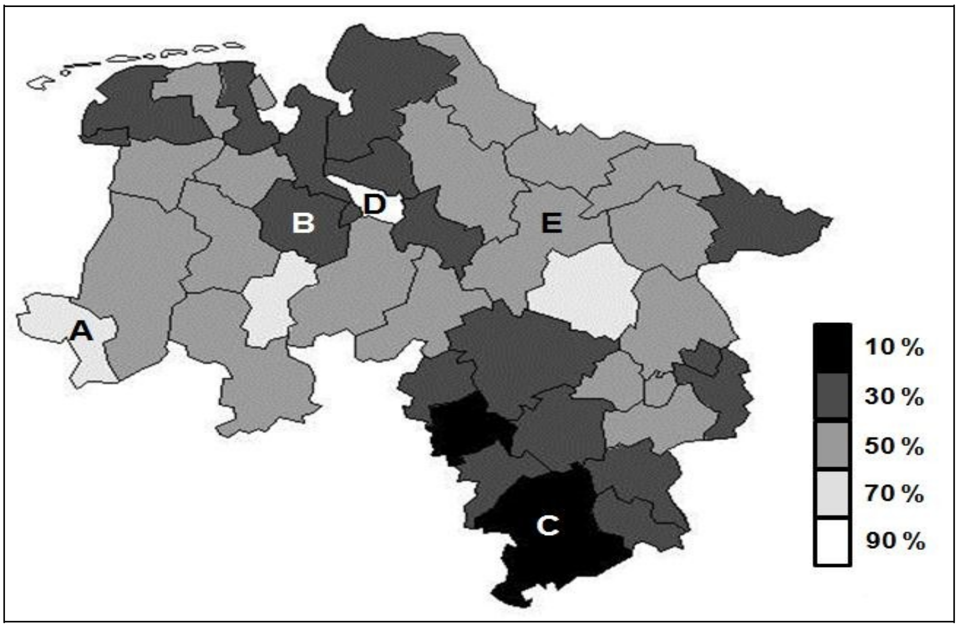


Which the most likely area at picture 1 (A,B,C,D,E) that matches the arrow of 3D map on the topographic map at picture 2?

a) A b) B c) C d) D e) E

PART D

PART D

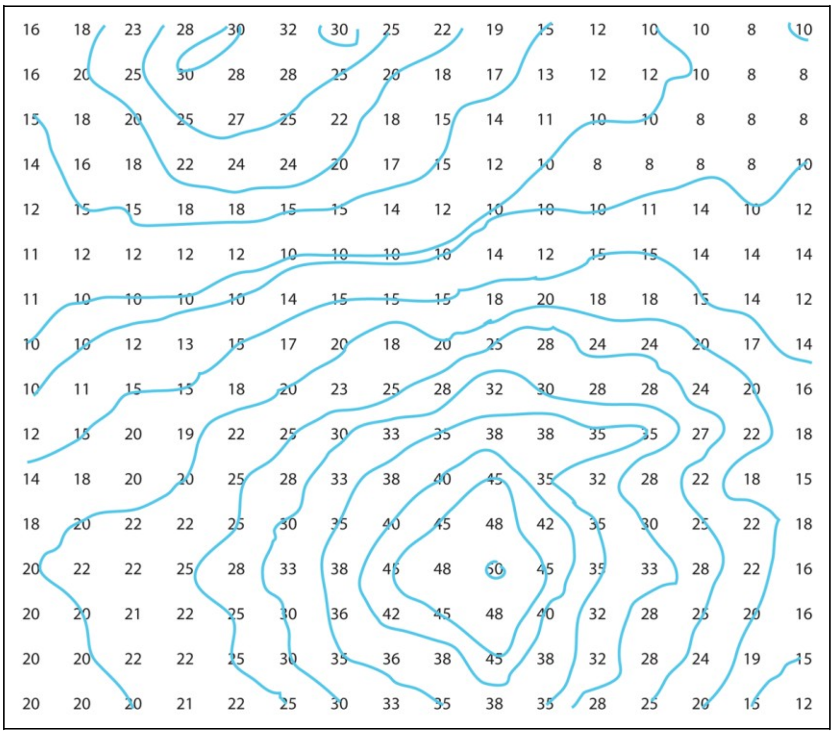


1. A prediction map and its variance can be produced by using Kriging. Kriging method takes a small number of observations to produce a prediction map. Above is an example of **variance map** using Kriging. Variance is a measure of how far a set of numbers is spread out. The legend/variance is represented in the right hand side of the map. According to the map, which area of observation needs more data/observation value to produce a better Kriging map?

   a) A   b) B   c) C   d) D   e) E

PART D

2. Contour lines are lines that connect the points that have same heights (blue line). Below is an example of contour lines using contour interval of 5. Contour interval is the step of elevation. Using contour interval of 5 means that there will be an increase or decrease of 5 units between certain areas within the depicted region.



How many hills you see in the picture above?

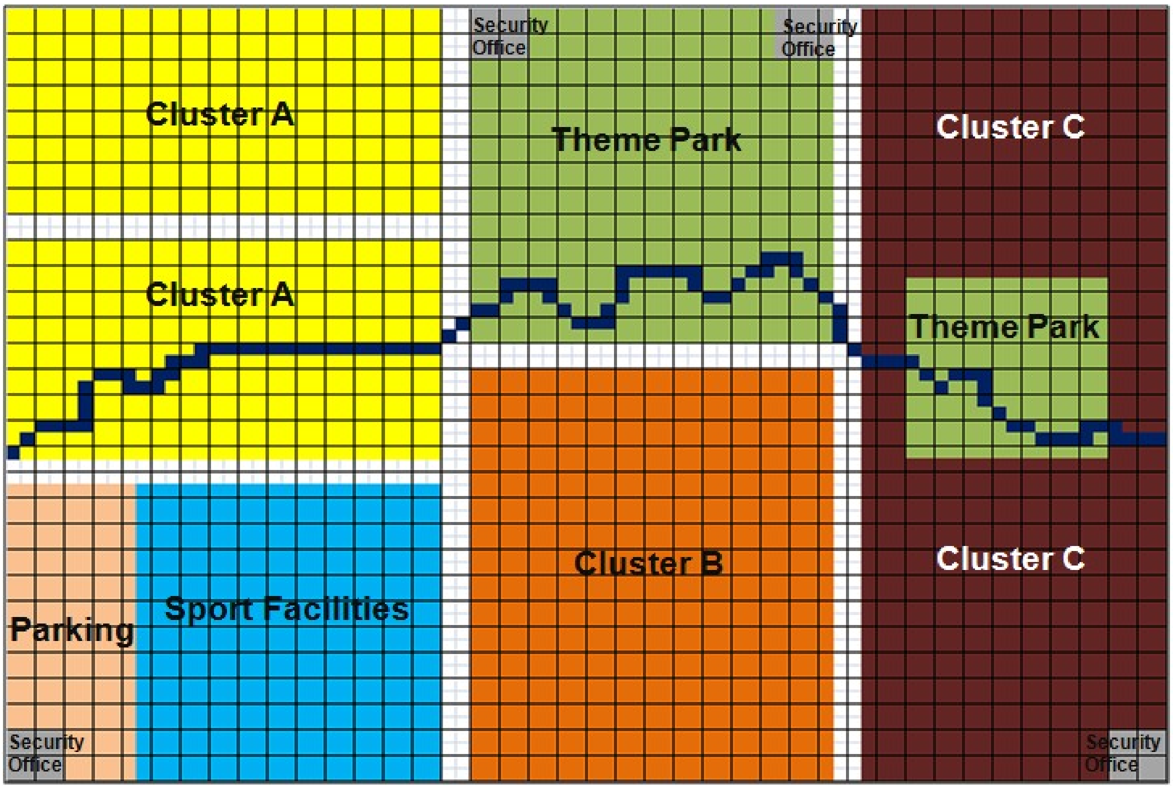
a) 1 b) 2 c) 3 d) 4 e) 5

3. Suppose that every square formed by grid points in the picture above is a 25 (=5x5) square unit area, how many plains (flat area) which are larger than 50 square units would you see?

a) 1 b) 2 c) 3 d) 4 e) 5

PART D

Answer the questions number **4 and 5** based on the map below.
The picture below is a town house layout consisting of three clusters of housing. Each square of on the picture is 5m x 5m.



4. How many square meters is cluster C? Include the area of the river in the cluster C to obtain your answer.

   a) 6450 b) 6500 c) 6550 d) 6600 e) 6650

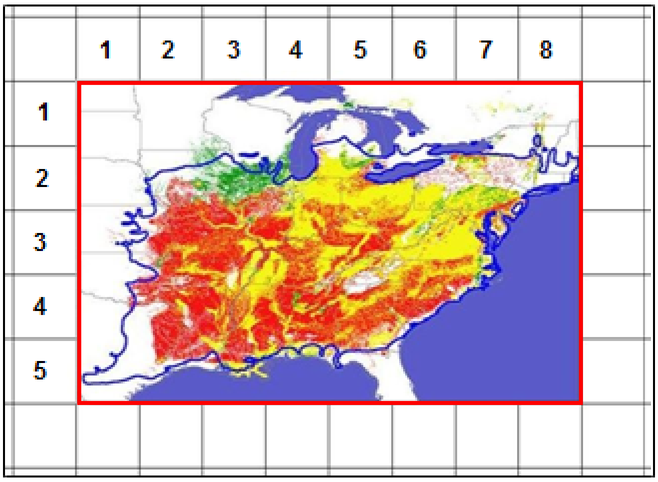
5. You are about to build houses in Cluster C which as much as possible fill in cluster C. However, there are some rules that have to be taken into account, such as:
   a. Cluster C should be filled with houses with area of 7.5mx10m.
   b. Each house must have an access to the main street (represented by white area in the picture before). Therefore, in each cluster including cluster C there should be small streets connecting each house in that cluster to the main street. At least one side of each house should be connected to the small streets in each cluster.
   c. Each house in each cluster should be at least 10m away from the river.
   d. The vacant area in each cluster should be kept minimally.

   How many houses can be built in cluster C?

   a) 65 b) 64 c) 63 d) 62 e) 61

PART D

Answer the questions number **6 and 7** based on the map below. Consider that the whole (total) area in the red box is an area of 8x5 square units

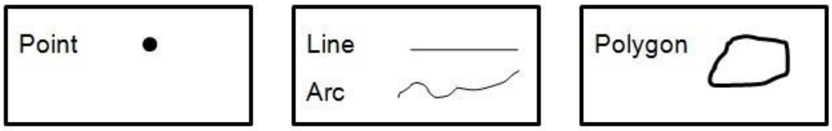


6. According to the map above, how much is approximately the area of the green region relative to the total area?
   a) 2.5%
   b) 5%
   c) 1%
   d) 7.5%
   e) 10%

7. How much is approximately the area of the red region relative to the total area?
   a) 66%
   b) 15%
   c) 20%
   d) 22.5%
   e) 33.3%

PART D

Please classify the objects mentioned in number **8 to 10** below using point, line (arc), or polygon (area).



e.g. people, trees　　e.g. road, footpath　　e.g. lake, island

8. Small cities of countries in a 1:1.000.000 map of a region….
   a) Points
   b) Lines
   c) Area
   d) Lines and Area
   e) Points and Lines

9. Ponds and ducks in a nature map….
   a) Points
   b) Lines
   c) Area
   d) Area and Lines
   e) Area and Points

10. A map of city subway….
    a) Points
    b) Lines
    c) Area
    d) Lines and Area
    e) Points and Area

Appendix IV. Table of Content of the DVD that accompanies the thesis report.

Content of the DVD that accompanies this report:

Main Folder	Sub folder	Files	Description
1. REPORT			Consists of 2 files: • Thesis report in Ms. Word • Thesis report in PDF
2. SPATIAL THINKING TEST MATERIAL		1. Spatial thinking pre-test	Spatial thinking test material used for the pre-test in the Netherlands. The test is in English.
		2. Spatial thinking test_29 June 2015_UNS	Spatial thinking test material for test in UNS - Indonesia. The test is in Indonesia language.
		3. Spatial thinking test_30 June 2015_STPN	Spatial thinking test material for test in STPN - Indonesia. The test is in Indonesia language.
3. DATA SCORING IN EXCEL		Thesis data	Consists of an excel file. This file contains of the test results of four groups: MGI students, 1st year STPN students, 2nd year STPN students and students from the Sebelas Maret University. Moreover, there is a mean calculation of the four groups in combination with several graphs showing the number of correct answers for the four parts of the test.
4. DATA ANALYSIS IN SPSS	1. 1st year vs 2nd year STPN_GIS	1st year vs 2nd year STPN students.sav	A file in .sav format, which contains variables of the scores for 1st and 2nd year STPN students used for analysis and validation in SPSS software.

Main Folder	Sub folder	Files	Description
		Output_1st year_vs_2nd year STPN.spv	The output of the independent samples t-test for the mean scores of 1st and 2nd year STPN students.
	2. GIS and non GIS	GIS vs non-GIS.sav	A file in .sav format, which contains variables of GIS and non-GIS students score for analysis and validation purposes, used in SPSS software.
		Output_GIS_vs_non GIS.spv	The output of the independent samples t-test for the mean scores of GIS and non-GIS students.
	3. Gender_1st year STPN	Gender_1st year STPN.sav	A file in .sav format, which contains variables of 1st year STPN male and female students score for analysis and validation purposes, used in SPSS software.
		Output_t_test_gender_1st year STPN.spv	The output of the independent samples t-test for the mean scores of male and female students of 1st year STPN.
	4. Gender_non GIS	Gender_non GIS.sav	A file in .sav format, which contains variables of non-GIS male and female students score for analysis and validation purposes, used in SPSS software.
		Output_gender non GIS.spv	The output of the independent samples t-test for the mean scores of male and female of non-GIS students.
5. LITERATURES			PDF-file consisting of the list of references used.