



Cartography M.Sc.

Master thesis

Open Educational Resources (OER) for Teaching Thematic Mapping

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2022

Statement of Authorship

Herewith I declare that I am the sole author of the submitted Master's thesis entitled:

"Open Educational Resources (OER) for Teaching Thematic Mapping"

I have fully referenced the ideas and work of others, whether published or unpublished. Literal or analogous citations are clearly marked as such.

Vienna, 1 September 2022

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September, 2022

SUPERVISORS:
Barend Köbben



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Disclaimer

This document describes work undertaken as part of a programme of study at the Faculty of Geo-information Science and Earth Observation of the University of Twente. All views and opinions expressed therein remain the sole responsibility of the author, and do not necessarily represent those of the Faculty.

ABSTRACT

Cartography is making maps, and maps are a part of cartography. The International Cartographic Association defines cartography as the discipline related to the art, science and technology of making and using maps. In this study, we are focused more on cartography as a technique. Thematic cartography is one of Cartography's domains closely related to the observed and extracted attributes, where a thematic map is a final product. As is well known, thematic cartography is focused more on how one can produce maps with specific techniques as hard skills. Hard skill is an ability obtained through repetition, practice, and education. Therefore, education is necessary to provide the abilities described above and plays an important role.

This study concentrates on the thematic cartography teaching given to university students. The existing methods carry out involving various materials, namely through textbooks or also delivering material in class in thematic cartography courses. Learning about thematic mapping or thematic cartography can be done through various methods. Open Educational Resources or after this referred to as OER can be defined as a teaching and learning resource used by anyone under a specific property license. Based on this definition, OER can be a potential tool for teaching thematic cartography. However, so far, there is no OER that we are aware of does implement the syllabus for teaching thematic cartography. First, we investigated how the university's syllabus and curricula have been implemented. Afterwards, we implemented it to our OER, so the students could learn from it. From this, we expected to determine the potential and the relevance of OER in teaching thematic cartography curricula.

To achieve the aim of this research, we developed a web-based OER prototype called "*THEMPE: THEmatic Mapping Practice and Explanation*". Our main target groups are bachelor's and master's students. We are eager to teach them thematic cartography by implementing OER the similar learning goals as the thematic mapping course in the universities. Furthermore, implementing the teaching syllabus helped us create a learning path that is easier to follow by the students. For building our web-based OER prototype, we used Bootstrap as an open-source CSS framework which helps to create a responsive web. Then, we used Vega-lite to display and visualise data into a thematic map. Finally, we included Javascript for more functionalities, such as gamification, on the web-based prototype. The prototype contents include visual variables, thematic map types and how to map the data. After finishing the OER prototype, it is also necessary to evaluate the prototype. This evaluation aims to see how high potential of OER as a new tool for teaching thematic cartography and its relevance. The evaluation used for determining the potential of THEMPE is a method called "remote unmoderated usability testing". The potential mentioned here means how OER can be one of the methods for teaching thematic cartography to achieve learning goals. Meanwhile, relevance means how the prototype successfully implemented the syllabus or teaching investigation result.

To determine the potential of our prototype, the user testing we have done is highly related to usability; therefore, we examined three terms in usability, i.e. effectiveness, efficiency, and satisfaction. We obtained 56 submitted pretest responses, but only 48 completed tasks were reported from the participants. For effectiveness, we are eager to reveal the correlation of it to the partic-

ipants' correct answers and completed tasks. As mentioned before, our main target is students in universities. However, we also considered the non-student users keen on learning thematic mapping, so we expected to reach a wider audience. After user testing, we reported 85.71% completed tasks from the number of responses we mentioned beforehand. This rate is sufficient to achieve our effectiveness goals. Then, we could see that the answers to questionnaires show that 70.8% of participants answered correctly in both the pretest and post-test. The questions correctly answered in both the pretest and post-test mean that the participants are familiar with thematic mapping, and the questions are easy. It can be proved by how 60.4% and 66.7% of participants agreed that the pretest and post-test questions are easy, respectively. Moreover, we reported that 16.7% of participants answered the questions correctly in the post-test. This number showed us that THEMPE provided a clear explanation, so they learned something from THEMPE. Hence, we could conclude that THEMPE had achieved the effectiveness goals.

Furthermore, the following term we examined is the efficiency of THEMPE. It correlates to how well THEMPE features work as they are supposed to, i.e. the overall design, the gamification (lock-unlock with quiz), the practices part (where you can play), the material, and the way of explaining. Also, how participants think that learning with THEMPE is less effort than learning in the class, THEMPE can access it everywhere and anytime they want, and everyone freely accesses THEMPE. We reported that most participants agreed with the statements given in the questionnaires regarding the efficiency mentioned beforehand. Therefore, we concluded from user testing results regarding efficiency that THEMPE reached the efficiency goals.

In addition, the last term to explain is the satisfaction of THEMPE. It is represented by the ratings of the gamification, design, materials, exercise/game of each page, the way of explaining, and the quizzes. We calculated the average rating for each aspect and reported that all aspects achieved more than 4.40 out of 5.00. This number showed us that each aspect of THEMPE had successfully satisfied our users. Afterwards, we looked into the relevance of THEMPE. The relevance could be investigated by examining the proof of how input from the expert interviews and syllabus reviews was implemented in THEMPE. We included all the proof and concluded that we projected the input successfully to our prototype. Hence, we could conclude that "*THEMPE: THEmatic Mapping Practice and Explanation*" as an OER had excellent potential for teaching thematic mapping and has high relevance with the input we got before the prototype implementation.

THEMPE is available online on: <https://zulfanaa.github.io/thempe>

Keywords

Open Educational Resources, Teaching, Cartography, Thematic Cartography, Thematic Mapping

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List of Abbreviations

CSS Cascading Style Sheets. 8, 20, 25

GIS Geographic Information System. 2, 5, 6, 48, 56, 63, 68

HTML HyperText Markup Language. 8, 20, 25

ICA International Cartographic Association. 1, 2, 63

ISO International Organization for Standardization. 28, 42, 45

JS JavaScript. 8, 20, 25, 26

JSON JavaScript Object Notation. 26

OER Open Educational Resources. i, ii, 2–7, 12, 14, 16, 17, 19, 20, 23, 25, 27–29, 31, 33–35, 42, 43, 45, 48–50, 55–59, 63–66, 69

RO Research Objectives. 3

RQ Research Questions. 3

RQ1 Research Question 1. 11–14, 55

RQ2 Research Question 2. 12, 16, 19, 55, 56

RQ3 Research Question 3. 12, 28, 56

SVG Scalable Vector Graphics. 26

THEMPE THEmatic Mapping Practice and Explanation. 21, 25, 27, 31, 32, 34, 35, 37, 38, 40–43, 45–50, 56–59

Chapter 1

Introduction

1.1 MOTIVATION AND PROBLEM STATEMENT

Cartography is making maps, and maps are a part of cartography. As defined by the International Cartographic Association (ICA) below:

“Cartography is the discipline dealing with the art, science and technology of making and using maps”

If we look at it from a scientific perspective, nowadays, most scientific cartography is closely related to spatial knowledge. For example, how cartography provides the knowledge about creating a map or the users so they can understand their surroundings spatially. As for cartography as an art, it can be said that the purpose of art is more difficult to express. It relates to how we create a map by paying attention to the aesthetics of the map to show the reader. Robinson, 2011 also explained cartography as a visual technique with three components of visual elements: lettering, structure and colour. In this study, we are focused more on cartography as a technique.

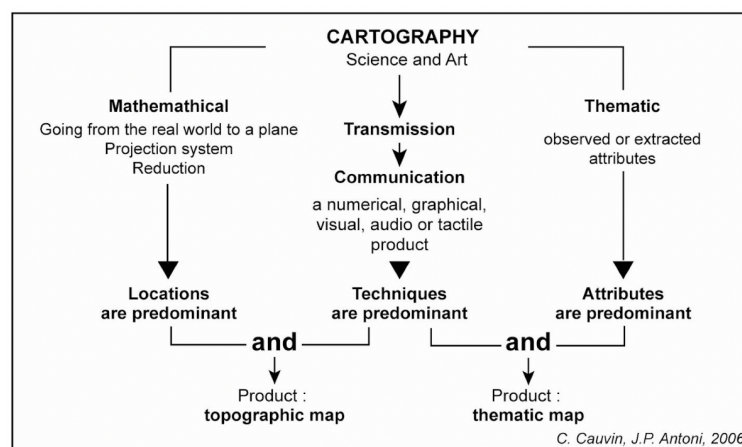


Figure 1.1: Cartography and its domain

Furthermore, in Cauvin, Escobar, & Serradj, 2013 it is explained how cartography is defined and classified according to its domain. As noted in Figure 1.1, we looked further into thematic cartography. Thematic cartography is closely related to the observed and extracted attributes. After that, techniques and attributes are dominant and produce a thematic map as the product.

Thematic cartography is focused more on how people can produce maps with specific techniques as hard skills. Hard skill is an ability obtained through repetition, practice, and education.

Education is necessary to provide the abilities described above and plays an important role. First, we would like to mention what is written in <https://education.icaci.org/education-material/>, that the ICA Commission on Education and Training as a forum with the mission:

"to maintaining an overview of cartographic and geospatial education worldwide; delivering presentations, papers, workshops and contributions to other programmes which focus on educational material in the subject of cartography and geospatial information science and technology; and to investigate and report on technologies, concepts and methods of educational and training courses"

On the page owned by this forum above, there are several educational materials in the form of literature or textbooks, valuable online resources for Cartography and GIS theory and tutorials, and other forms to provide knowledge to others who want to learn cartography. This shows us that learning about cartography can be done through various methods.

This study concentrates on the thematic cartography teaching given to university students. The existing teaching methods usually use textbooks or also deliver material in class in thematic cartography courses. As one of the hard skills that students must possess, this is where students have to do many exercises to gain and strengthen their abilities in thematic mapping.

Open Educational Resources or after this referred to as OER is teaching, learning, and research resources that are published publicly or have been released under a specific intellectual property license which permits the free use or reuse by other people or institutions ((The Higher Education Authority, 2009) in Marcus-Quinn & Diggins, 2013). Based on this definition, it proves that OER can be a potential tool for teaching thematic cartography. This OER can be shared with students more efficiently and easily accessed. Students need easy access to learning materials and must practice as much as possible to master thematic mapping. However, so far, there is no OER that we are aware of does implement the syllabus for teaching thematic cartography. So in this research, we are eager to make a web-based OER prototype called *"THEMPE: THEmatic Mapping Practice and Explanation"* that can be used by students who are our target groups. Our target groups are bachelor's and master's students, so OER adapts similar learning goals of teaching thematic cartography or thematic mapping in universities. Furthermore, implementing the teaching syllabus helps us create a learning path that is easier to follow by the students. We desire the students to learn by themselves and deepen their knowledge of thematic mapping from our web-based OER prototype.

In the realisation, for producing our web-based OER prototype, we have utilised Vega-lite to display and visualise data into a thematic map on each exercise of map type materials. Furthermore, Bootstrap is the framework for developing the web we used in the prototype. The prototype contents include visual variables, thematic map types and how to map the data. We adopted the contents from several sources and the teaching thematic mapping materials. After finishing the OER prototype, it is also necessary to evaluate the prototype. This evaluation aims to see how high the potential of OER as a new tool in teaching thematic cartography is. The evaluation used a quantitative method we called remote unmoderated usability testing. The potential mentioned here means how OER can be one of the methods for teaching thematic cartography to achieve learning goals. In addition, we learned how the syllabus and curricula had been implemented in the universities where our target groups study thematic cartography. After that, we investigated the relevance of our OER content to what these students are learning. From this, we expect that we

can determine the potential and the relevance of OER in teaching thematic cartography curricula.

1.2 RESEARCH IDENTIFICATION

1.2.1 Research Objectives (RO)

The main objective of this research is to implement the traditional thematic cartography teaching syllabus into open educational resources and test its potential to be used to teach thematic cartography. For more detail and depth, we have several Research Objectives (RO) in this study.

RO1 Identifying the syllabus of teaching method in university for teaching thematic cartography

RO2 See how we can implement the syllabus as an open educational resource

RO3 Determining the potential and relevance of open educational resources for teaching thematic cartography

1.2.2 Research Questions (RQ)

Under the research objectives written above, the following are Research Questions (RQ) that need to be answered in this study.

RQ1 Questions regarding the current method of teaching thematic cartography

RQ1A How is the syllabus for teaching thematic cartography defined and delivered to the students in university?

RQ1B How is the thematic cartography teaching syllabus different for bachelor's and master's students?

RQ2 Questions regarding the open educational resources

RQ2A What are Open Educational Resources (OER)? What is the advantage of it? How is the development of OER recently?

RQ2B How can the thematic cartography teaching syllabus be implemented in Open Educational Resources?

RQ3 Questions regarding the potential and the relevance of open educational resources

RQ3A How high is the potential and relevance of OER for teaching thematic cartography?

1.2.3 Innovation of Research

Teaching thematic cartography in the university is arranged in the syllabus, and the contents of the lectures are designed so the students can learn the hard skill of thematic mapping. Open Educational Resources (OER) is a potential tool for teaching thematic mapping. However, no OER

we are aware of does currently implement the syllabus for teaching thematic cartography to students. In this research, we are eager to implement a syllabus for teaching thematic cartography for bachelor's and master's students. Afterwards, we determined the potential and the relevance of OER for teaching thematic cartography to the students. From the measurements, we could see how much students can learn from OER. Hence, this research investigated the existing teaching method and OER.

1.3 THESIS OUTLINE

This research's outline follows the research questions to give a systematic overview of how we answered each question. As a result, this is the outline of the research:

- **Chapter 1 - Introduction :** In the current chapter, we explained this research's motivation, problem statement, and research identification.
- **Chapter 2 - Background and Related Works :** This chapter discusses and mentions the previous research or works related to this current research.
- **Chapter 3 - Methodology :** In chapter 3, we discussed and mentioned the methods used in this research in general terms.
- **Chapter 4 - Open Educational Resource for Teaching Thematic Mapping :** this chapter discusses how the methods from the previous chapter are implemented in this research specifically.
- **Chapter 5 - Results Interpretation :** This chapter discusses the result interpretation about potential and relevance as the final research question of this research. The interpretation of the results is explained and discussed in detail.
- **Chapter 6 - Discussion :** Finally, in this chapter, we have done the conclusion of the whole research and mentioned the limitations. Future development and research will be discussed in this chapter as well.

Chapter 2

Background and Related Works

This chapter discusses and mentions the previous research or works related to this current research.

This research concerns the teaching of thematic cartography and the potential for its implementation in open educational resources. Several OER were published before this research, but they still lack specifics for teaching thematic cartography. Therefore, the studies and literature reviewed in this related work are divided according to the research focus. Teaching thematic mapping is the first topic to be discussed. Then, we examined how educators teach in universities with the existing teaching method. Furthermore, we mentioned the previous work on teaching thematic mapping online with OER. Therefore, the related works to OER were also written in this section. Afterwards, we provided our review and the reading summary on the related works regarding prototype establishment and evaluation.

2.1 TEACHING THEMATIC CARTOGRAPHY AND EDUCATION

Teaching is the foundation of education. The existing teaching method can be in the form of literature or textbooks, helpful online resources for Cartography and GIS theory and tutorials, and other forms to provide knowledge to others who want to learn cartography. These methods show us that learning about cartography can be done through various methods.

There has been a trend change in teaching methods for cartographic education in the last 50 years. Ormeling, 2008 explained how cartographic education changed over time, from drawing expertise and analogue reproduction to digital production and reproduction. The research of Ormeling, 2008 shows how cartographic education has changed since 1957. A table shows the distribution of students' theses topics in his research. It proves that from 1960 to 2007, they showed a significant interest in topics related to digital reproduction, which continues to increase over time as technology develops. On the other hand, the interest in map reproduction decreased over time. Ormeling, 2008 states that the changes in paradigm influenced the trends very much. First, the digital revolution brought us closer to map use focus. The second major paradigm change concerns the separation of map analysis function, storage function, and communication & exploration function. The third major paradigm change, led by the geo-visualization revolution, brought us to the separation of communication cartography and analytical cartography.

The trend change in teaching leads to a new pedagogical model for students. The previous work from Harvey & Kotting, 2011 presents the new pedagogical model for students who are curious about mapping but absent of desire to become cartographers. It mentions that due to cartography's evolution, educators tend to use more GIS and computer technologies to emphasize

the training of cartographic specialists, especially on thematic cartography and geo-visualization. This research from Harvey & Kotting, 2011 discusses the application of active learning and scaffolding to a mapping course for digital natives. They have done several steps for applying the way of teaching, i.e., surveys and feedback, problem-solving hands-on learning assignments, group interaction facilitation, and error messages. Afterwards, they found three main obstacles: getting students interested; developing necessary hardware and software skills; dealing with technology, and overcoming the related learning curve challenges for teachers and students.

Thematic mapping is a cartographic process of making a thematic map. The thematic map itself is a map which can represent the various geographic phenomena(s), the location, and the information of its attribute at the same time. The goal of this map is to show the audience statistical information that usually can not be understood directly from tables or graphs (UN & Association, 2020). Teaching thematic mapping has been done in various ways of teaching. In the university, the teachers provide teaching materials for the students. The students can access the textbooks. Nonetheless, there is a method to teach thematic mapping online. For instance, the GIS&T Body of Knowledge from the University Consortium for Geographic Information Science: <https://www.ucgis.org/gis-t-body-of-knowledge>

The teaching method for geo-visualization often involves the students actively in the teaching process. For example, the SDI (Spatial Data Infrastructure) light approach from Köbben et al., 2010 trains the students to keep actively involved in the learning process until the visualization of geospatial data upon cartographic design principles. Furthermore, in Murad-Al-Shaikh & Cartography, 2009 students are actively giving map critiques for a GIS - Cartography course. There are six lectures and eight maps to critique. The lectures are preliminary concept, qualitative symbology, layout and visual balance, quantitative symbology, and name placement. The map critique is guided by an instructor who is the teacher of the course, and the students are actively following the procedure of map critique. Another class activity where the students are actively involved is discussed in research by Briwa & Wetherholt, 2020 about teaching critical cartography in the Geography classroom. The learning objective of this class is to enable the students to think about the perspectives from critical cartography to maps in a hands-on group activity. How the students actively give the class feedback allows the teacher to evaluate the teaching method's effectiveness, as shown in the research of Nieścioruk, 2016. The evaluation for teaching effectiveness involves using mental and sketch maps as the tool where the students are allowed to apply their knowledge from geodesy and cartography class.

2.2 OPEN EDUCATIONAL RESOURCES

Marcus-Quinn & Diggins, 2013 states how Open Educational Resources (OER) defined by UNESCO in 2002 and the Higher Education Authority (HEA) of Ireland in 2009 as the learning, teaching, and research resources that are released publicly which can be used or reused by everyone under a specific intellectual property license. Therefore, OER has a great potential to reduce the cost of developing education quality. The review from Atkins, Brown, & Hammond, 2007 for reporting on The Hewlett Foundation Open Educational Resources Initiative achievements, challenges, and new opportunities has been done in detail to provide how the development of OER is. This review mentions that the sustainability of OER is becoming a concern.

The sustainability of OER means that the OER has a long-term viability for all concerned

(Downes, 2007). However, the definition varies; for some researchers, the OER is sustainable when it can represent a cheaper alternative to accomplish a similar task than the mechanism currently employed. In the research of Downes, 2007, the researcher discusses the models for sustainable OER and divides the discussion into the funding model, technical model, content model, and staffing model. The funding model consists of the endowment model, membership model, donations model, conversion model, contributor-pay model, sponsorship model, institutional model, governmental model, partnership and exchange. Furthermore, for the technical model, the researcher mentioned free use, used locally and resources are adapted, downloaded, and sent back to the system repository and potential use by others. The researcher stated two content models: reusability of the contents and the license associated with the resource. Finally, for the staffing model, the researcher introduces the producer-consumer model or co-producer model.

Teaching thematic mapping can be taught with OER. There are several published OER on the internet. The first example is the GIS&T Body of Knowledge for Cartography and Visualization(<https://gistbok.ucgis.org/knowledge-area/cartography-and-visualization>) which was established by the University Consortium of Geographic Information Science (UCGIS). UCGIS aims to support the GIS&T higher education community and the connections sustainably. This digital version was launched in 2016 and then built entirely and directly from the first GIS&T Body of Knowledge, which was published in 2006. The second example is "Cartography playground" (<https://cartography-playground.gitlab.io/>) created by Moritz Brunnengräber, which was built as a result of a master thesis at the Chair of Cartography at the Technical University of Munich. Cartography Playground is an interactive website for elaborating cartographic algorithms, problems and other cartography-related matters. It aims for the students of cartography who are keen to deepen their knowledge. The final example of OER for teaching thematic mapping is "Thematic Map Tutor" (<https://kartoweb.itc.nl/TMT/>) by Köbben, 2018. Thematic Mapping Tutor is an OER for teaching thematic mapping where the students can learn about the nature of data, the perception properties, and visual variables. The students can try making a map on this web page with the data provided.

2.3 PROTOTYPE PRODUCTION

The prototype can be defined as the representation of pre-production, which includes some aspects of a specific concept or final design (Camburn et al., 2017). In the article written by Camburn et al., 2017, three crucial things for producing a prototype. The first one is the objectives for design prototyping. The most cited objectives are refinement, communication, exploration, and active learning. The second thing is the guidelines for incorporating prototyping in the design process. Camburn et al., 2017 mentioned testing, timing, idea, fixation, feedback, usability, and fidelity in this section. The final thing to be considered is a framework for design prototyping strategies. A prototyping strategy combines several techniques to achieve the prototyping effort's objective.

The diverse role of prototyping is discussed in the research of Elverum, Welo, & Tronvoll, 2016 entitled "Prototyping in New Product Development". It notes that prototyping can vary depending on the research domain, from engineering design, human-computer interaction, and Design Thinking to software development. Thus, they give different prototype cases, such as prototyping in the development of an inflatable seat belt. Furthermore, more about software prototyping has been researched by Berzins, 2003, who states that software prototyping is an approach which is helpful for the developers and the users to communicate about the visualization of a system they

proposed in an iterative process as is shown in Figure 2.1.

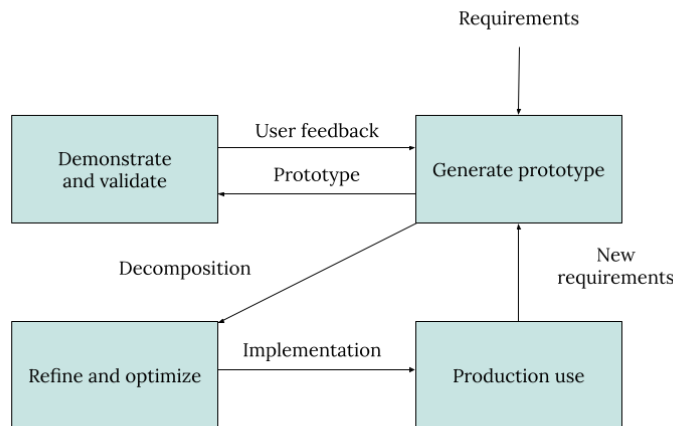


Figure 2.1: The software prototyping process adopted from Berzins, 2003

Prototyping for a web page requires tools to support data visualization. There is an article about layer grammar of graphics from Wickham, 2010 entitled "A layered grammar of graphics". This article describes the extensions and refinements developed while building an open-source implementation of the grammar of graphics for R ggplot2. It states that the components of the layered grammar are layers (data and mapping, statistical transformation, geometric object, and position adjustment), scales, coordinate systems, and faceting. All of the components are arranged in a default hierarchy.

Vega-Lite is a tool used for visualizing geospatial data in a web-based prototype. Satyanarayan, Moritz, Wongsuphasawat, & Heer, 2017 writes the research about Vega-lite as a grammar of interactive graphics, which enables rapid specification of interactive data visualizations. The Vega-Lite compiler can generate the output Vega specification in four phases, i.e.:

1. Parse → the compiler parses a Vega-Lite specification to disambiguate it
2. Build → the compiler builds an internal representation of this unambiguous specification, including the tree of models
3. Merge → the compiler merges redundant components from the model trees
4. Assemble → the compiler assembles the requisite Vega specification

Bootstrap is the tool for developing Cascading Style Sheets (CSS) framework. One review paper on Bootstrap Framework is written by Gaikwad & Adkar, 2019 that states that Bootstrap is an open source framework of HTML, CSS, and JS, which enables a responsive web page and user-friendly. According to this review paper, Bootstrap is easy to use, supported by nearly all browsers, and provides a responsive design.

2.4 PROTOTYPE EVALUATION / USER TESTING

The evaluation of the prototype is necessary. One evaluation method is usability testing, often used interchangeably with "user testing". Based on the article written by Moran, 2019, usability testing is essential for the evaluation with the aims of identifying some troubles in the design/product/service, uncovering opportunities to improve, and learning about the target user's behaviour and preferences. The elements of usability testing are the participants, the tasks, and the researcher.

User testing has been done by several researchers in various fields for different research goals. For instance, Popelka, Vondrakova, & Hujnakova, 2019 has done the eye-tracking evaluation of weather web maps. This research aims to identify the potential usability problems of weather web maps, identify the strengths and weaknesses of the evaluated weather maps, and point out the differences between strategies in using maps by the respondents. The researcher evaluated five weather web maps, i.e. DarkSky, In-Pořcasí, Windy, YR.no, and Wundermap, using SMI RED 250 eye-tracking. This research for web weather maps has three sections of evaluation/usability testing: introductory, dynamic and static. The Introductory section is for recognizing and viewing maps, the dynamic section is where users can interact with the map, and the static section is where the user must answer questions to compare one map with another in the form of screenshots.

The research by Vogel, Kurti, Milrad, & Kerren, 2011 entitled "An Interactive Web-Based Visualization Tool in Action: User Testing and Usability Aspects" presents the evaluation of an interactive web-based visualization tool developed for supporting environmental sciences learning called "LET'S GO". This research has done a web-Map prototype usability test. It conducts the usability evaluation by collecting data, including tasks, questionnaires, screen capturing, and follow-up interviews. The study recruits students as the participants since the application is strongly related to student work. Students collect the geo-tagged content and its attributes to be added to "LET'S GO".

Master thesis research by Ioseliani, 2021, which designs the prototype of a travel map by adding the decision-relevant information, has evaluated the prototype in different scales of zoom: global, local, and spot level. In this research, there are three methods of user research, i.e. thinking aloud, questionnaire, and expert interviews. For the prototype evaluation, one section explains the study structure and the pretest given to the participants. Then, the evaluation conducts in the online questionnaire using QuestionPro as a tool. In the questionnaire, there are qualitative and quantitative questions regarding the prototype. The structure of the survey consists of the introduction of the prototype, participants' overview, system recommendation, responses to the itinerary, responses to base maps, and summary. Pretest tests are only for 3 participants with specific experience with the prototype.

Chapter 3

Methodology

This chapter discusses and mentions the methods used in this research in general terms.

The methodology of this research is summarized in Figure 3.1 chart below:

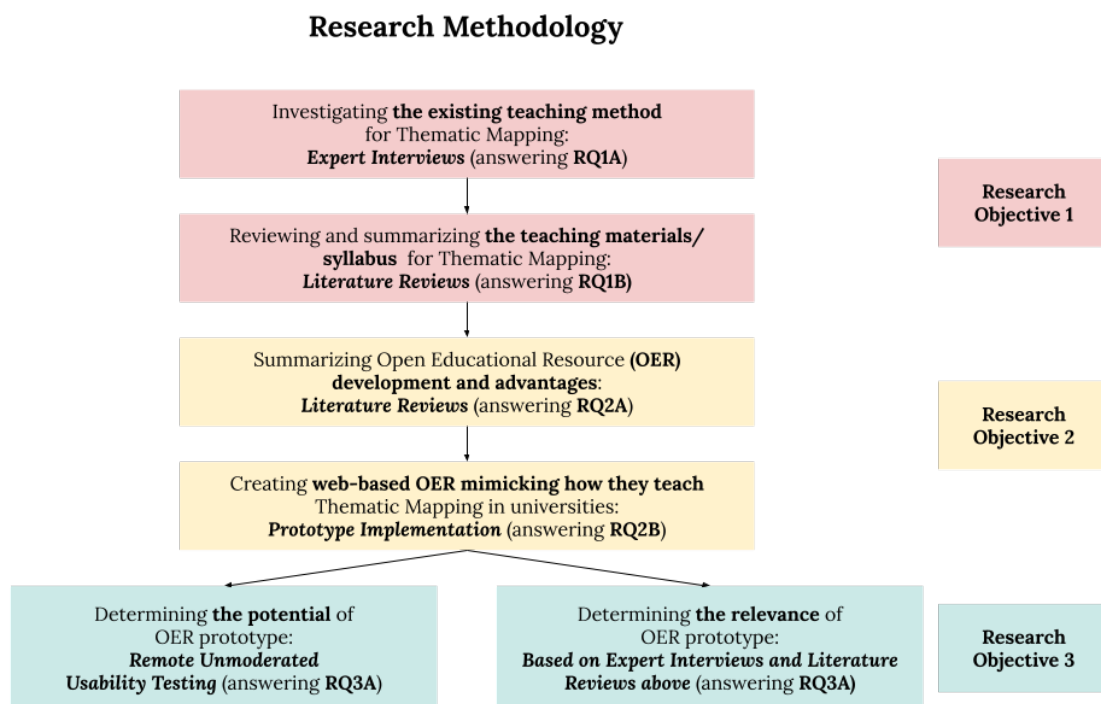


Figure 3.1: Research Methodology Workflow

3.1 EXISTING TEACHING METHOD FOR THEMATIC CARTOGRAPHY/MAPPING IN UNIVERSITIES

The method for answering the Research Question 1 (RQ1) regarding the current method of teaching thematic cartography:

3.1.1 Expert Interviews

The interview is one of the data collection methods for qualitative (direct) data. In order to answer Research Question 1 A (RQ1A), the interview specifically involved the experts, called an expert interview.

3.1.2 Syllabus Reading: Literature Review

The literature review is the method of collecting information from several reliable sources. Since this research is strongly related to teaching, the literature review specifies in the syllabus reading review to answer Research Question 1 B (RQ1B).

3.2 OPEN EDUCATIONAL RESOURCE STUDY

To answer Research Question 2 A (RQ2A), the study about OER had done with a literature review. As mentioned in the previous section, the literature review is the method to collect information from several reliable sources.

3.3 WEB-BASED OER PROTOTYPE BUILDING

Thematic mapping teaching syllabus implemented in an OER prototype to answer Research Question 2 B (RQ2B)). The prototype can be defined as the representation of pre-production, which includes some aspects of a specific concept or final design (Camburn et al., 2017). The prototype is web-based and can be accessed through the internet.

3.4 PROTOTYPE EVALUATION

The method for answering Research Question 3 (RQ3):

3.4.1 User Testing

Usability testing is used to answer Research Question 3 A (RQ3A). This method gets information about the potential of the OER prototype.

3.4.2 Expert Interviews and Literature Review for Syllabus

In order to prove the relevance of OER, we had done the same method for answering RQ1.

Chapter 4

Open Educational Resource for Teaching Thematic Mapping

This chapter discusses how the methods from the previous chapter are implemented in this research specifically.

4.1 HOW THEMATIC MAPPING IS TAUGHT IN THE UNIVERSITIES

Teaching thematic mapping or cartography in the universities with the existing method can be different in different countries and universities. To investigate the teaching method and answer RQ1A, below is the explanation of the method implementation for this research.

4.1.1 Expert Interviews

The interview is a semi-structured interview which involved six experts from different universities in different countries. The experts are teaching thematic mapping or thematic cartography for bachelor's and master's students from different study programs, namely:

1. ITC - University of Twente: Master of Geoinformation and Spatial Engineering
2. Technische Universität München: Bachelor of Geodesy and Geoinformation and Master of Land Management and Geospatial Science
3. Technische Universität Wien: Bachelor of Geodesy and Spatial Planner
4. Technische Universität Dresden: Bachelor of Geography, Geodesy, and Educational Geography
5. Gadjah Mada University: Bachelor of Cartography and Remote Sensing
6. University of Wisconsin-Madison: Bachelor's and Master's from various programs

4.1.2 The technical guide

The interviews were held under our technical guide, where the experts are considered interviewees. The technical guide was sent to the interviewees before arranging the interview appointment, which consisted of 3W+1H (3 "What" questions and 1 "How" question), namely:

1. What? This interview is about the method that the teacher use for teaching thematic mapping or thematic cartography
2. When? The interview will be held on the educator's preferred date and time as the source. The duration of this interview is 35-45 minutes
3. Where? This interview will be an online interview at a zoom link which will be shared the day before the interview is conducted as a reminder.
4. How? After the educator accepts the interview request, the appointment will be arranged. The researcher will lead the interview, asking the question, which will be explained in the next section. The interview will be audio-recorded as the interview documentation, but only if it is allowed by the interviewees.

The questions for the experts are about the number of students who join the thematic mapping course and the background of the students, the language of the thematic mapping course, the method and learning objectives of the thematic mapping course, the organisation of the thematic mapping course, and the thoughts about another method of teaching thematic mapping (online teaching or teaching with tools). Later, we used some input from the expert interview result as the baseline for answering the following research question regarding OER prototype implementation. The shortest summary of the expert interview result can be seen in Figure 4.1. Finally, we attached the detail of the result from the expert interviews in the last section of the thesis manuscript.

01	The most important thing in the class	Theory behind and application of techniques
02	Organization of the course	Lecture and exercise. The teachers prefer to have active learning.
03	Online teaching vs in-class teaching	In-class teaching is preferable, but online teaching is possible by increasing student engagement

Figure 4.1: The Shortest Summary of Expert Interviews

4.1.3 The list of the syllabus for bachelor's and master's students

The teaching materials or syllabus come from and for bachelor's or master's students from different universities under different course names. These materials are listed in Table 4.1 to answer RQ1B. The review shows that the syllabus and teaching materials for bachelor's and master's students are not considerably different. The table of syllabus review summary proved the previous statement is attached below. Moreover, there is one syllabus which is designed for both bachelor's and master's students. Later, we considered some input from the syllabus review as the baseline for answering the following research question regarding OER prototype implementation. All the materials are summarised and can be seen in Figure 4.2.

Bachelor	Master	Bachelor and Master
SOURCE 1: <ol style="list-style-type: none"> 1. Mapping and Map use 2. Definition of Base Map 3. Data acquisition for thematic mapping 4. Thematic map design 5. Thematic map composition 6. Data classification for thematic maps 7. Generalization 8. Qualitative & quantitative mapping 9. Physical Mapping 10. Cartographic communication 11. Statistical diagram 12. Thematic map symbol design 13. Qualitative statistical data mapping 14. Quantitative statistical data mapping 15. Cartogram 16. Colour theory in cartography 17. Graphic semiology 18. Information Analysis 	SOURCE 1: <ol style="list-style-type: none"> 1. Why use graphics? 2. Why use maps? 3. Graphics tell the story of the data 4. Cartographic process 5. Visual variables 6. Graphic Grammar 7. Perception 8. Perception properties 9. Choice of map type 10. Qualitative Thematic map types 11. Quantitative Thematic map types 	SOURCE 1: <ol style="list-style-type: none"> 1. Introduction to Cartography 2. Map Projections 3. Map Scale & Generalization 4. Map Typography 5. Putting it All Together I: Visual Hierarchy & Layout 6. Symbolization 7. Choropleth Maps 8. Proportional Symbol Maps 9. Dot Maps and Dasymeric Maps 10. Isoline Maps 11. Cartograms
SOURCE 2: <ol style="list-style-type: none"> 1. Introduction to Cartography & History of Cartography 2. Graphic-based elements: based design principles 3. Visual variables 4. Classification methods 5. Layouting 6. Relief 7. Coordinate system and projection 8. Generalization 9. Map interpretation 	SOURCE 2: <ol style="list-style-type: none"> 1. Geovisualization 2. Understanding users 3. Cartographic Generalization 4. Thematic Mapping Techniques 5. Map Design 6. Geospatial Database Systems 7. Selected methods and technologies for Web Cartography 8. Introduction to GIS-based spatial analysis tools 	
SOURCE 3: <ol style="list-style-type: none"> 1. Human-machine communication 2. Animation and interaction 3. Map criticism and map editing 4. Thematic visualisation techniques 5. Thematic map design 6. Journalistic cartography 7. Copyright of maps 8. Geobrowser and Kepler.gl 9. Usability testing 	SOURCE 3: <ol style="list-style-type: none"> 1. GISs and maps 2. The visualization process 3. The visualization strategies: present or explore? 4. The cartographic toolbox 5. How to map, qualitative data, quantitative data, terrain elevation, and time series 6. Map cosmetics 7. Map dissemination 	
SOURCE 4: <ol style="list-style-type: none"> 1. Data types 2. Graphic variables 3. Methods of data visualisation 4. Graphical design 5. Layout 6. Perception and cognition 		

Figure 4.2: The Summary of Syllabus Review

Table 4.1 Teaching Materials or Syllabus Reviewed

Title	Source
Thematic Cartography	Gadjah Mada University (Arranged by: Sudaryatno and Totok Wahyu Wibowo for Bachelor of Cartography and Remote Sensing)
Cartography II (Kartographie II)	TU Munich (Arranged by: Christian Murphy for Bachelor of Geodesy and Geoinformation)
Introduction to Cartography	University of Wisconsin-Madison (Arranged by: Robert E. Roth for Bachelor's and master's students from various majors)
Basic of Cartography	TU Dresden (Arranged by: Dirk Burghart for Bachelor's students of Geodesy, Geography, and Educational Geography)
Applied Cartography	TU Wien (Arranged by: Andrea Binn for Bachelor's students of Geodesy and Spatial Planner)
Visualisation - GI Science and Modelling	ITC (Arranged by: Barend Köbben)
Chapter 10: Visualisation and dissemination Page 347 of The Core of GIScience: a process-based approach	ITC (Arranged by: Rolf de By, Otto Huisman, Menno-Jan Kraak)
Visualisation of Geodata and Cartography	TU Munich (Arranged by: Christian Murphy for Master of Land Management and Geospatial Science)

4.2 OPEN EDUCATIONAL RESOURCE

To answer the research question RQ2A regarding Open Educational Resources (OER), we explained the literature review result in the sub-sections below.

4.2.1 What is Open Educational Resources (OER)?

From the literature review, there are some definitions of OER:

1. The term OER was discussed at UNESCO's 2002 Forum on Open Courseware:
"Open Educational Resources designates teaching, learning and research materials in any medium, digital, or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no limited restrictions. Open licensing is built within the existing framework of intellectual property rights as defined by relevant international conventions and respects the work's authorship."
2. The Higher Education Authority (2009) in Marcus- Quinn & Diggins (2013):
"Open Educational Resources can be defined as teaching, learning, and research resources that

are in the public domain or have been released under an intellectual property license that permits their free use or reuse by others."

3. Bell, Steven (2022). "Research Guides: Discovering Open Educational Resources (OER): Home". <https://guides.temple.edu/OER>. Retrieved 2022-05-29:

"Open Educational Resources are educational materials and resources that are publicly accessible, meaning that they are openly available for anyone to use and under some licenses to re-mix, improve and redistribute."

4.2.2 Open Educational Resources (OER) advantages

From the literature review, there are some advantages of OER:

1. **Less cost**

Downes (2007) states that there is still discussion regarding the cost of OER; some researchers state that OER is free, and others would like to call it affordable. However, OER usually is freely available and can be accessed by everyone.

UNESCO's 2002 Forum on Open Courseware mentioned that Open Educational Resource permits no-cost access (OER definition). Moreover, the declaration in a world OER congress by UNESCO also stated that: "OER has a great potential for reducing the cost of expanding quality education."

The Higher Education Authority (2009) in Marcus- Quinn & Diggins (2013) stated how the "Creative Commons" license for OER makes OER can be accessed with no cost for the users.

2. **Can be accessed by everyone from everywhere**

Daniel (2006) in Downes (2007) mentioned that open resources should be accessible, appropriate, accredited, and affordable. It means everyone from everywhere should easily access OER.

The Higher Education Authority (2009) in Marcus- Quinn & Diggins (2013), in its definition of Open Educational Resources, states that OER permits their free use or reuse by others.

Bell, Steven (2022), in their definition of OER, mentioned that Open Educational Resources are supposed to be publicly accessible, which means OER is available to anyone.

3. **Under a specific license, it is available for some people to contribute**

Bell, Steven (2022), in their definition of OER, mentioned that Open Educational Resources, which has a special license, OER allows the others to re-mix, improve and redistribute.

Rob, E, Roth (personal communication, 31 May 2022) stated that we could take OER to the next level by publishing OER publicly with DOI and allowing people to contribute.

4.2.3 Open Educational Resources (OER) development

From the literature review, the development of OER is written in the table 4.2 below:

Table 4.2: OER Development

Begin of Table		
Year	Source	OER development
In the late 1990s	Marcus-Quinn & Diggins (2013)	The Open Educational Resources movement originated
In 2002	Marcus-Quinn & Diggins (2013)	MIT released 50 freely available courses through the Open Course-Ware initiative
Set up and funded in 2005 and went full service in 2010	Marcus-Quinn & Diggins (2013)	The National Digital Learning Resources (NDLR) service is an open educational resource service. It provides an open on-line repository and community portal. This OER is shared between 7 universities and 14 institutes of technology in Ireland.
2006	GITTA was funded by the Swiss Virtual Campus, a program initiated by the Swiss Confederation	http://www.gitta.info/website/en/ It is mentioned in GITTA Home that: <i>GITTA (Geographic Information Technology Training Alliance) is a platform offering e-learning content as Open Educational Resources (OER). A pool of over 40 e-learning lessons covers the following thematic areas: GI Systems, Data Capture, Data Management, Spatial Modeling, Spatial Analysis, and Cartographic Presentation. Content is in large parts multi-lingual, with English, German, and French materials.</i>
Starting in 2016	The GIS&T Body of Knowledge by the University Consortium of Geographic Information Science	https://gistbok.ucgis.org/ It is mentioned in their "About" section that: <i>This Body of Knowledge documents the domain of geographic information science and its associated technologies (GIS&T). By providing this content in a new digital format, UCGIS aims to continue supporting the GIS&T higher education community and its connections with the practitioners, employers, and clients who comprise the increasingly diverse collection of GIS&T professionals.</i>

Continuation of Table 4.2		
Year	Source	OER development
2018	OpenGeoEdu is a project that four project partners create from German Universities, non-universities and Research Institutions	https://learn.opengeoedu.de/gis It is mentioned in the project information that: <i>The project is intended to illustrate the use of open data offers in such courses using best-practice examples and, based on this, provides e-learning offers for integration into such courses.</i> The authors: Prof. Dr.-Ing. Ralph Bill of the University of Rostock, Dr.-Ing. Gotthard Meinel of Leibniz Institute for Ecological Spatial Development (IÖR), Dr.-Ing. Michael Hovenbitzer of the Federal Agency for Cartography and Geodesy (BKG) and Dipl. Geogr. Andre Brosowski of DBFZ German Biomass Research Center gGmbH
Published 2018	Thematic Mapping Tutor by Barend Köbben	https://kartoweb.itc.nl/TMT/ Thematic Mapping Tutor is an OER for teaching thematic mapping where the students can learn about the nature of data, perception properties, and visual variables. The students can try making a map on this web page with the data provided.
Published 2021	Cartography Playground by Moritz Brunnengräber, which was built as part of a master thesis at the Chair of Cartography at the Technical University of Munich.	https://cartography-playground.gitlab.io/ The authors stated on the website that: <i>Cartography Playground is a simple and interactive website for explaining cartographic algorithms, problems and other matters. It is aimed at students of cartography who want to refresh and deepen their knowledge.</i>
End of Table		

4.3 BUILDING AN OPEN EDUCATIONAL RESOURCE PROTOTYPE

The prototype implementation was based on expert interviews, and syllabus and teaching materials review. The input from the experts inspired the contents and design of the prototype. The detail of the prototype implementation to answer RQ2B will be explained afterwards.

4.3.1 Prototype Implementation

The prototype of OER aims to give the students a chance to learn online about thematic mapping with the exciting teaching method, which can be done independently. The prototype mimics

how educators teach thematic mapping or thematic cartography in the universities and adjust the learning goals to the same goal. This way, we expected the students would achieve the learning goal effectively.

The result of the expert interview states that the essential metiers in the class are the theory behind thematic mapping or thematic cartography and the application of techniques. Furthermore, the class consists of lecture sessions and practice/exercise sessions, so active learning is the most preferable among the teaching experts. Active learning allows the students to be involved more and develop their hard skills for thematic mapping. The educators mentioned that in-class teaching is preferable. However, online teaching is possible and can be more effective by increasing student engagement. Based on the input from expert interviews, we developed the overall concept of OER web-based prototype.

Web-based Open Educational Resources

Web-based prototype of OER is easy to build and be accessed by everyone at any anytime. The prototype implementation employed Vega-Lite and Bootstrap libraries that involved HTML, CSS, and JS.

Practice or exercise part

The input from the educators on experts' interviews inspired this practice or exercise part. They said that as educators, they always have exercise classes or practice sessions that allow students to learn actively and give them more space to explore their knowledge.

Gamification

One of the experts stated that gamification is an excellent method to keep the students interested in learning and increase student engagement. From Pakinee & Puritat, 2021 who wrote about Designing a gamified e-learning environment for teaching undergraduate courses based on the big five personality traits: The gamified learning platform can improve students' performance (Attali and Arieli-Attali 2015; Denny 2013), motivational affordance (Marcos et al. 2014), and attitude (Glover 2013). In their research, the researchers set up the research to compare students' performance in non-gamified e-learning and gamified e-learning. They gave pretests and post-tests to the students to test their knowledge. They found differences between the groups of students who learn with non-gamified e-learning and gamified e-learning. They stated that gamified e-learning improves student engagement in long-distance learning. This research also found that the students' personalities can affect their participation.

The result of the syllabus and teaching materials review is the next part of the prototype baseline. From the review, the contents of the prototype are designed for bachelor's and master's students, as seen in Figure 4.3. In this research, the most covered contents are for thematic mapping and focused on the map types. The prototype provides only three common map types: Choropleth Map, Proportional Symbol Map, and Flow Map.

The input from the answer to the previous research question inspired OER prototype design

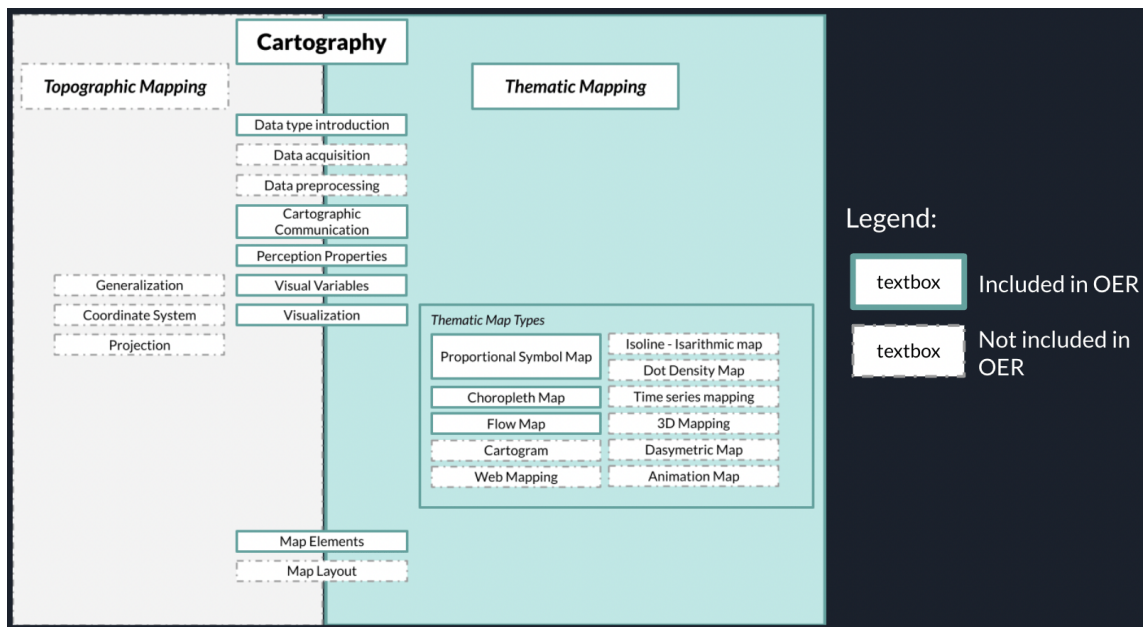


Figure 4.3: The Summary of Syllabus Review

and contents. From there, the learning path should be designed to encourage the students to learn based on what they are supposed to understand first. The gamification allows for creating the obvious learning path by enabling lock-unlock features. The students can only learn further materials after they have understood the previous materials.

The prototype has the practice/exercise part and the explanation of a specific topic in thematic mapping. Hence, we gave the name to the prototype **THEMPE**, which is the acronym of **Thematic Mapping Practice and Explanation**. The home page of THEMatic Mapping Practice and Explanation (THEMPE) can be seen in Figure 4.4 below.

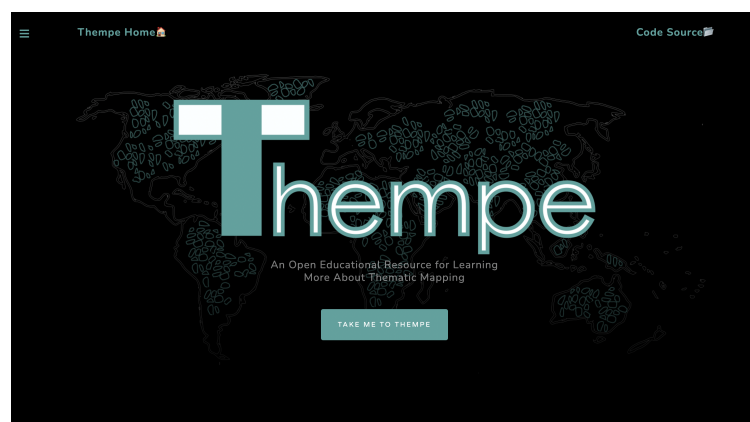


Figure 4.4: THEMPE home

Below is the list of the contents for the prototype:

1. THEMPE Home Sub-contents:

- (a) What is THEMPE?
 - (b) THEMPE contents
2. Introduction to Thematic Mapping Sub-contents:
- (a) What is thematic mapping?
 - (b) What is the goal of thematic mapping?
 - (c) Good map examples
 - (d) Where can I create a map? With software examples for creating a map
 - (e) Quiz 1: Introduction to Thematic Mapping
3. Cartographic Process Sub-contents:
- (a) What is Cartographic Process?
 - (b) Know about your data
 - (c) Know about the perception properties of your data
 - (d) Know what visual variable you need
 - (e) Exercise or practice part: Visual variable drag and drop objects
 - (f) Common Map Types
 - (g) Quiz 2: Cartographic Process
4. Choropleth map Sub-contents:
- (a) About Choropleth Map
 - (b) Choropleth Map Data
 - (c) Choropleth Map Color Scheme
 - (d) Choropleth Map Data Classification Method
 - (e) Exercise or practice part: A canvas for creating a Choropleth Map
 - (f) Quiz 3: Choropleth map
5. Proportional Symbol Map Sub-contents:
- (a) About Proportional Symbol Map
 - (b) Proportional Symbol Map Data
 - (c) Proportional Symbol Map Design Considerations
 - (d) Exercise or practice part: A canvas for creating a Proportional Symbol Map
 - (e) Quiz 4: Proportional Symbol Map
6. Flow map Sub-contents:
- (a) About Flow Map
 - (b) Flow Map Categories
 - (c) Flow Map Design Considerations
 - (d) Exercise or practice part: A canvas for creating a Flow Map
 - (e) Quiz 5: Flow map

7. Map Elements Sub-contents:

- (a) What are map elements?
- (b) Map frame
- (c) Map title
- (d) Map Legend
- (e) Orientation
- (f) Map scale
- (g) Map citation
- (h) Exercise or practice part: Arranging the map layout
- (i) Quiz 6: Map Elements

4.3.2 Prototype data collection

The source of images for the prototype comes from various web pages on the internet and is free to use. The link to each image is attached as a hyperlink to get the users directly to the source. Furthermore, the source of the contents comes from various OER and other textbooks freely accessed on the internet. All the references used in the OER are listed at the end of each page of OER. The source of image and content is intended to be from everywhere and is freely accessed by the users because we are eager to provide the users with more information from outside the OER but still easy to access from different sources. In addition, there is the source from other OER, so the users can also check the other source.

The data used for the practice/exercise part is downloaded from the United Nations Sustainable Development Goals Data Portal:

<https://unstats.un.org/sdgs/dataportal/>

Below is the list of the data used in the OER prototype:

1. Indicator 4.a.1 Series Proportion of schools with access to the internet for pedagogical purposes, by education level in percentage
2. Indicator 4.a.1 Series Proportion of schools with access to adapted infrastructure and materials for students with disabilities, by education level
3. Indicator 4.b.1 Series Total official flows for scholarships by recipient countries (millions of constant 2019 United States dollars)
4. Indicator 4.c.1 Series Proportion of teachers with the minimum required qualifications, by education level and sex in percentage
5. Indicator 4.1.1 Series Proportion of children and young people achieving a minimum proficiency level in reading and mathematics in percentage
6. Indicator 4.2.2 Series Participation rate in organised learning (one year before the official primary entry age) by sex in percentage

7. Indicator 4.3.1 Series Participation rate in formal and non-formal education and training by sex in percentage
8. Indicator 4.4.1 Series Proportion of youth and adults with information and communications technology (ICT) skills by sex and type of skill in percentage
9. Indicator 4.5.1 Series Parity indices (female/male, rural/urban, bottom/top wealth quintile and others such as disability status, indigenous peoples and conflict-affected, as data become available) for all education indicators on this list that can be disaggregated

We decided to use the data from United Nations since the target group of the prototype is international students from all European countries who studied thematic mapping or thematic cartography. Therefore, more audiences can understand data in the English version. Furthermore, the students can continue to do further data visualisation with the tutorial from Houtman & Roth, 2021 entitled "Mapping for a Sustainable World - QGIS technical supplement".

We used the data above in the Choropleth Map page and the Proportional Symbol Map page as shown in Figure 4.5 and Figure 4.6 below. However, we used dummy data for the last map type, Flow Map, because the visualisation with Vega-lite requires complex variables. The dummy data is created for quantitative and qualitative data so the students can see the different visual variables used for the data types.

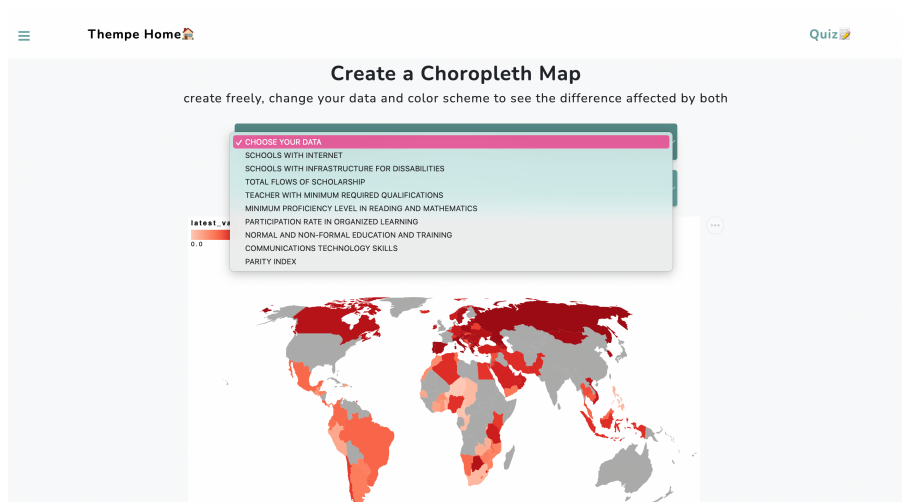


Figure 4.5: Practice/exercise part for Choropleth Map page

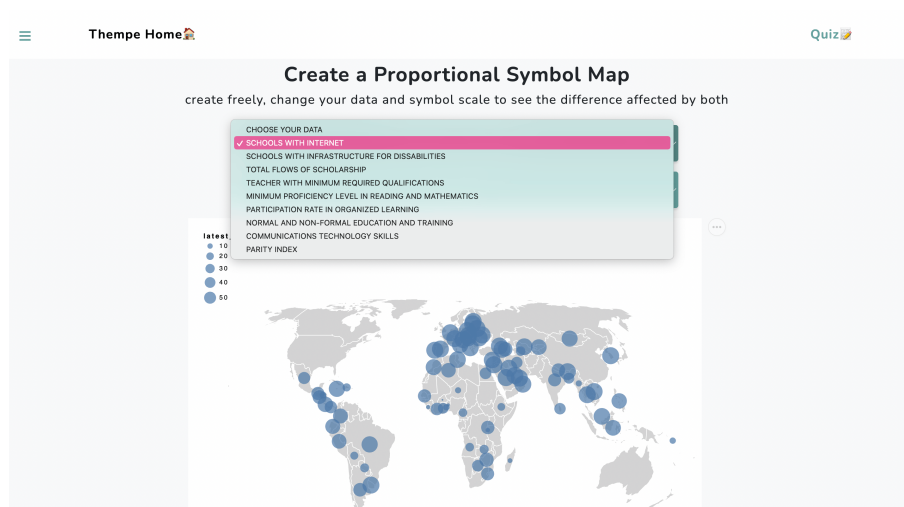


Figure 4.6: Practice/exercise part for Proportional Symbol Map page

4.3.3 Technologies Involved in Prototype Building

Bootstrap

Bootstrap is a tool for building a website. It is a free and open-source HTML, CSS, and JS framework which is directed at responsive, mobile-first front-end web development. The prototype utilised this tool because it is easy to use and get started, supported by nearly all browsers, and provides a responsive design. The responsive design is important for OER prototype since the target users are the students who use various gadgets to study, such as PC desktops and tablets. Thus, the students can study flexibly and access the website from any device without problems. The interface of THEMPE in both devices is shown in Figure 4.7 and Figure 4.8 below.

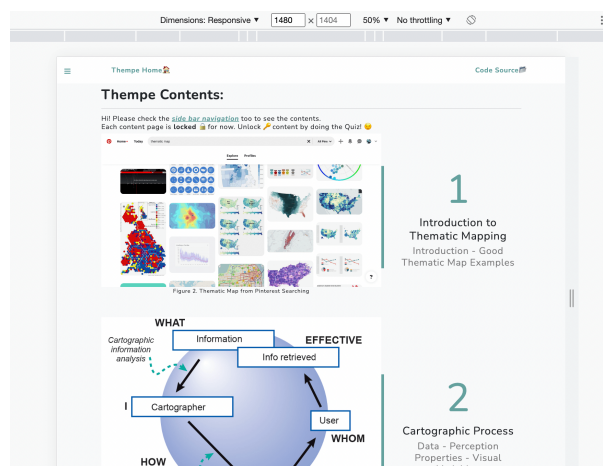


Figure 4.7: THEMPE in PC desktop

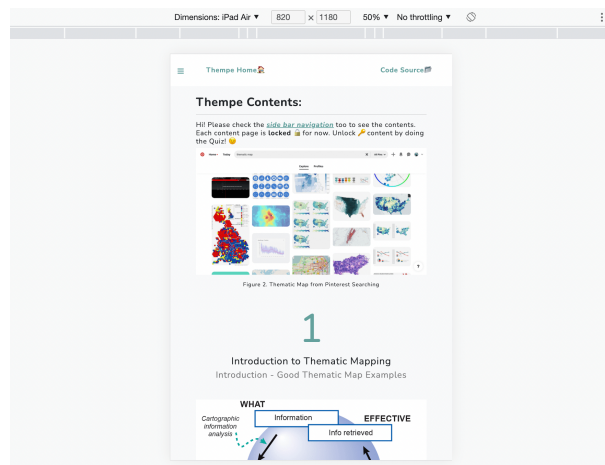


Figure 4.8: THEMPE in tablet

In this prototype development, we used JS to provide more functionalities to the prototype. The examples of this implementation can be seen in the part below:

1. Sidebar navigation (Figure 4.9)
2. Quiz on each page (the example is shown in Figure 4.9)
3. Practice part for visual variable in Cartographic Process page (Figure 4.10)
4. Practice part for map layout in Map Element page (Figure 4.11)

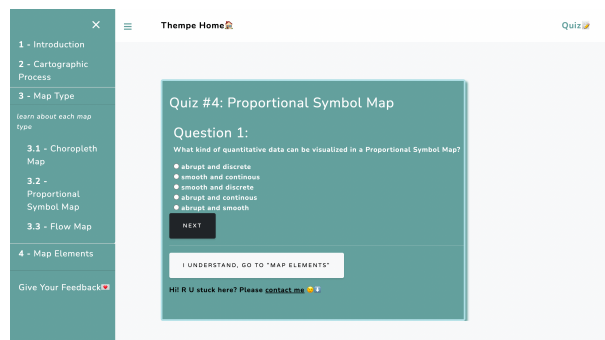


Figure 4.9: Sidebar Navigation and Quiz in Proportional Symbol Map page

Vega-Lite

Vega-lite is a high-level visualisation grammar which describes the visual appearance and interactive behaviour of visualisation in JavaScript Object Notation (JSON) and generates web-based views using Canvas and Scalable Vector Graphics (SVG). We used this tool to develop the practice part of Map Type pages, i.e. Choropleth Map page, Proportional Symbol Map page, and Flow Map page. One of the examples for Vega-lite implementation in the Choropleth Map page is shown in Figure 4.12.

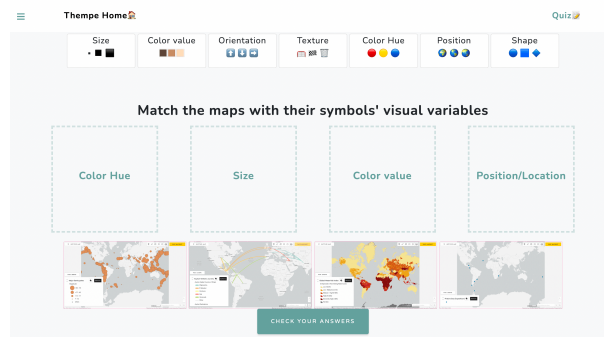


Figure 4.10: Variable visual practice in Cartographic Process page

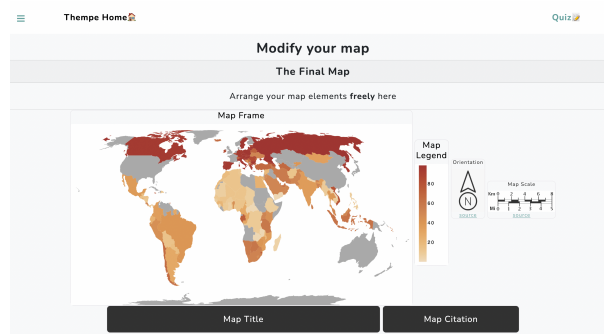


Figure 4.11: Map layout practice in Map Element page

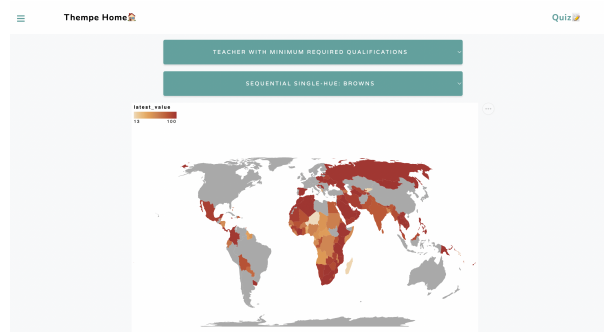


Figure 4.12: Vega-lite implementation for practice/exercise part in Choropleth Map page

THEMPE as a OER prototype is published in GitHub and open for public. GitHub is free and easy for everyone to access. It enables others to contribute to the project or ask the author to collaborate on the further step. It allows us to take the OER to the next level.

Below is the link to GitHub Repositories and GitHub page:

- GitHub Repositories: <https://github.com/zulfanaa/thempe>

- GitHub Pages: <https://zulfanaa.github.io/thempe/>

4.4 EVALUATION FOR OPEN EDUCATIONAL RESOURCES PROTOTYPE

The evaluation of the prototype is essential for proving how high the potential and relevance of the prototype for teaching thematic mapping. Therefore, the evaluation used a quantitative method, and the result of this evaluation will answer RQ3A. The potential mentioned here means how OER can be one of the methods for teaching thematic cartography to achieve learning goals. Afterwards, we investigated the relevance of our OER content to what these students are learning. From this, we expected that we could determine the potential and the relevance of OER in teaching thematic mapping or cartography. The detail of the evaluation will be given below.

4.4.1 The potential of Open Educational Resources Prototype

This evaluation is called usability testing or is often mentioned as user testing. The higher the usability, the higher the potential of the prototype for teaching thematic mapping or cartography. The term "usability", as it is written in International Organization for Standardization (ISO) 9241-11 (ISO, 2018), is very strongly related to how the targeted group of users could use a product, system or service to achieve a specific set of goals with effectiveness, efficiency, and satisfaction in a specified context of use. The meaning of effectiveness in this context is the accuracy and completeness of how the users can accomplish the specified goals. Then, efficiency means how satisfactorily the resources are used concerning the results achieved. Finally, satisfaction in this context means how the user's physical, cognitive, and emotional results from using the system, product or service fulfil the user's necessities and expectations. Hence, the context of use means the combination of users, goals, tasks, resources, and environment.

In this research, the specified context of use can be derived in detail below:

1. Users are the person who interacts with a system, product, or service, which in this context are bachelor's and master's students.
2. Goals are the intended outcome and in this research are how the students can achieve the learning goals and how students can understand the materials
3. Tasks are activities undertaken to achieve a specific goal. In this research, the tasks are strongly related to how the students do the pretest and post-test. From the test result, we analysed how high the abilities of the students to achieve the goals stated above.
4. Resources include time, human effort, costs and materials involved in creating a system, product, or service. In this research context, the research looked into how the features in this prototype work.
5. Environment includes the technical, physical, social, cultural and organisational environment. In this research, it strongly relates to the study environment of the students in universities.

In order to achieve the maximum result for this evaluation, the usability testing was held by setting up the method as shown from Figure 4.13. This research uses **Remote Unmoderated Testing**, which is the combination of "Usability Testing", "Remote Moderated Testing", and "Unmoderated Testing". This method intended result of the evaluation is in the middle of the landscape but more to the quantitative method. It aims to determine how high the potential of the OER prototype for teaching thematic mapping, which matches the fact that the quantitative user research aims to determine "how much" or "how many". In the middle of the behavioural vs attitudinal dimension, it aims to determine what people do (behavioural) and what people say (attitudinal). This means that the evaluation requires collecting objective and subjective data from the users.

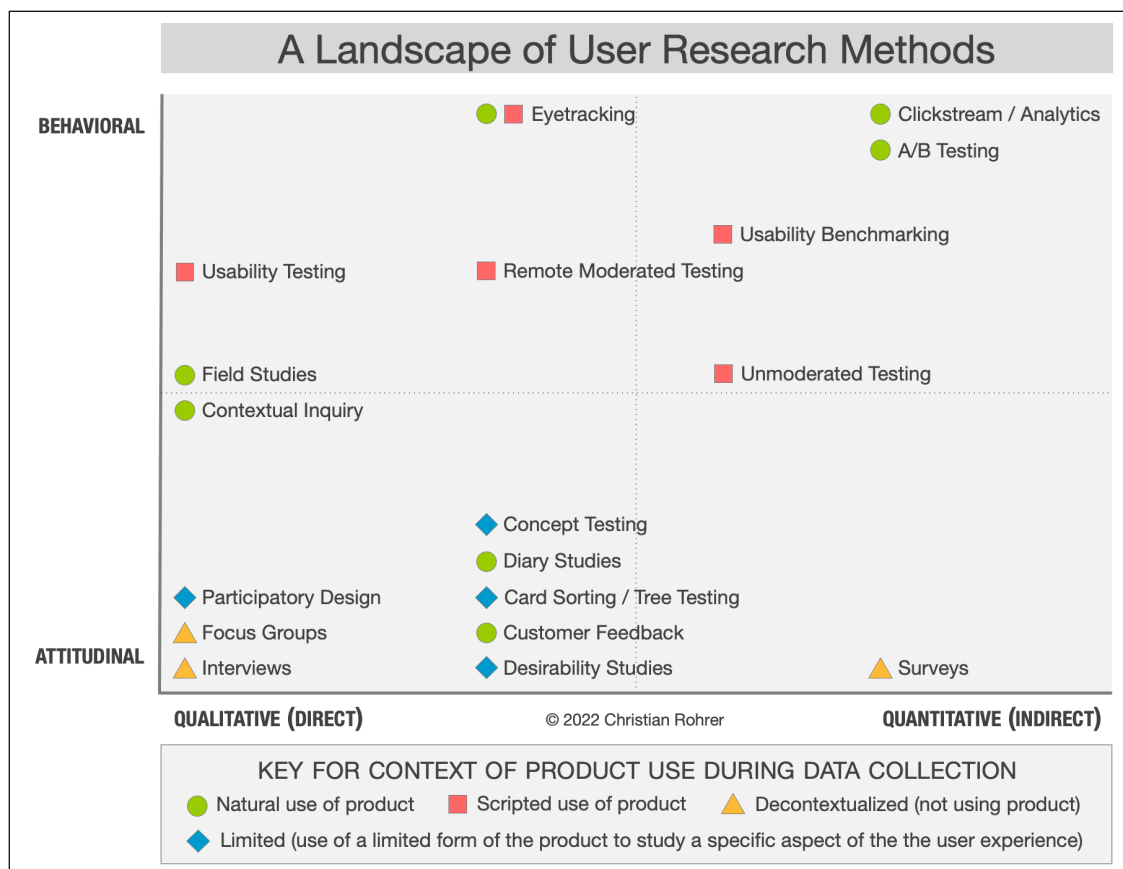


Figure 4.13: A Landscape of User Research Method from (Rohrer, 2022)

We used remote unmoderated usability testing in this research since the targeted groups of users are students from different countries. In addition, we included the non-student users as optional participants so that we could gain more insight. Moreover, in the result, we are eager to compare the result for student-only participants and all participants (including non-student users) to examine the potential for more users. For this reason, it enables us to gain a wider audience of OER prototype. The task of this usability testing is in the form of pretest and post-test questionnaires.

The question types on the questionnaires as the tasks based on 4.14 for both pretest and post-test. Firstly, in the middle of the behavioural vs attitudinal dimension, it requires the questions to determine what people do (behavioural) and what people say (attitudinal). Then, in the pretest

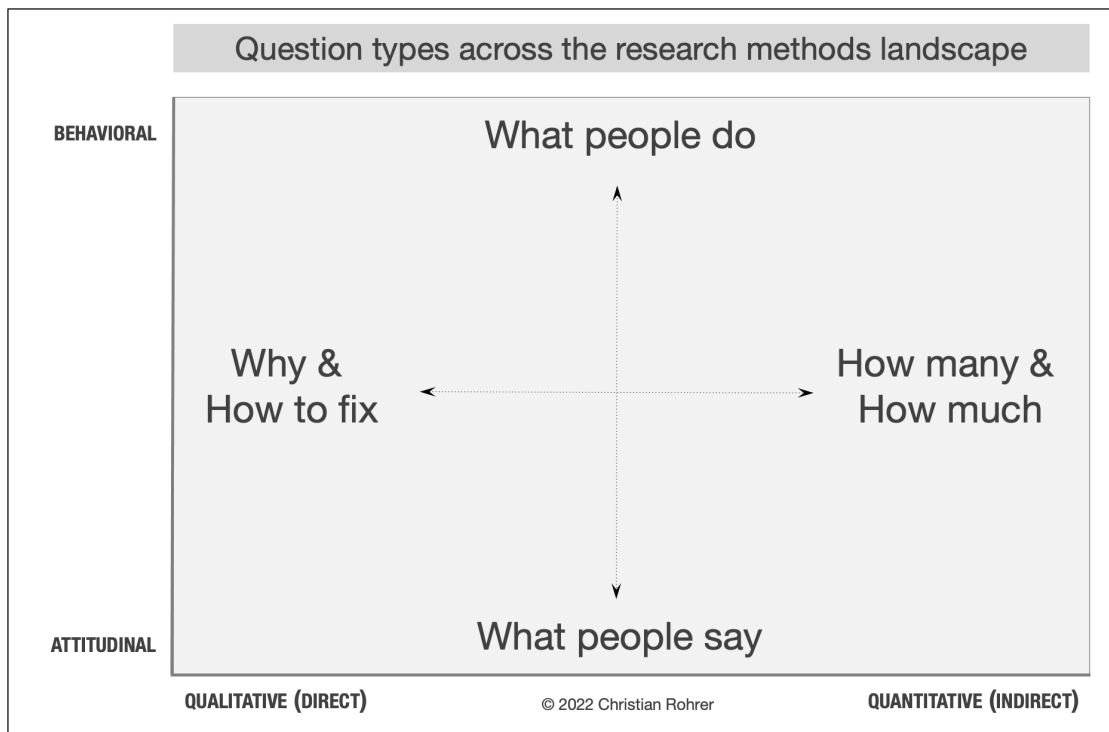


Figure 4.14: Question types across the research methods landscape from (Rohrer, 2022)

and post-test, there is a section where the students must answer the questions regarding thematic mapping or cartography. This section provides the information on "what students do", whether they answered it correctly or not, and it is considered an objective input. We included the questions in the quizzes on each prototype page so the students could learn from the prototype. For example, the question about the purpose of thematic mapping is shown in Figure 4.15.

Pretest - Thempe

Quiz related to Thematic Mapping/Thematic Cartography

Please do answer the questions, and do not be afraid of getting the wrong choice. This is not an exam.

What is the purpose of a thematic map?*

- ☐ to tell the audience about a specific geographical area
- ☐ to show a beautiful representation of information
- ☐ to visualize only geographic phenomenon distribution
- ☐ to represent one or more geographic phenomena, the location, and the attribute
- ☐ to show detailed statistical data

Figure 4.15: Pretest question

Meanwhile, to determine "what students say" as the attitudinal user research, which collects subjective input from students, there is the section where the question types are in the form of ratings, Likert scale, or ranking. The questions in this section allow the students to answer subjectively based on their thoughts about the given statements. For example, the statements regarding prototype feedback are shown in Figure 4.16. Since this evaluation uses a quantitative method, we give most of the questions in the pretest and post-test to determine how much students understand the materials and how high the prototype's potential for teaching thematic mapping is.

Quizzes*
Rate as much as you think that the quizzes are helpful for you to understand more about the materials

☆☆☆☆☆

I feel lock-unlock with the quiz is able to keep me excited learning from THEMPE*

Strongly disagree Disagree Neutral Agree Strongly agree

I feel more engaged with THEMPE as a teaching tool*

Strongly disagree Disagree Neutral Agree Strongly agree

What I like the most from THEMPE as an OER*
Change the order of these options below based on your preference

- ☐ The way of explaining
- ☐ The material
- ☐ The practice/exercise part (where you can play)
- ☐ The overall design
- ☐ The gamification (lock-unlock with quiz)

Reset

Figure 4.16: Post-test question

Regarding effectiveness, efficiency, and satisfaction, as we mentioned beforehand, this prototype evaluation is strongly related to the specified aspects below:

- Effectiveness: how the students can achieve the learning goals and how students can understand the materials. It is reflected by the completeness of the pretest and post-test. Moreover, the accuracy of the answers is considered as well. This accuracy is based on the questions section in both questionnaires, where students should answer the question. There are four possibilities for this, i.e. correct in pretest and post-test, correct in pretest, correct in post-test, and wrong in pretest and post-test.

- Efficiency: how the THEMPE features work as what it is supposed to be. We are eager to see how the side navigation bar helps to see the learning path, the quiz helps to understand the materials to answer pretest & post-test questions, and the practice part helps the students to perceive the given materials. Moreover, the questions are given in the form of ratings and the Likert scale to validate the expectation of OER advantages, as represented in Figure 4.17.

- Satisfaction: how good the feedback from students as the users is. The most important information to get is how they think about THEMPE design in general, the materials in THEMPE, the gamification implemented in THEMPE, what they like the most, and what can be improved

in THEMPE. The examples of questions given to the students are shown in Figure 4.17 as well.

Post-test - Thempe

Feedback for THEMPE Contents

The materials*
Rate as much as you think the materials are easily perceived by you

☆☆☆☆☆

The exercise and game of each page*
Rate as much as you like the exercise or practice section on each page. For example: The part where you can create your Choropleth Map

☆☆☆☆☆

The way of explaining*
Rate as much as you like the way of explaining in THEMPE

☆☆☆☆☆

I think learning with THEMPE is less effort than learning in the class*

Strongly disagree Disagree Neutral Agree Strongly agree

I like learning with THEMPE because I can access it everywhere and anytime I want*

Strongly disagree Disagree Neutral Agree Strongly agree

I like learning with THEMPE because it is freely-accessed by everyone*

Strongly disagree Disagree Neutral Agree Strongly agree

Figure 4.17: Post-test question regarding prototype feedback

Checklist for Unmoderated Remote Usability Testing



1. Define study goals



2. Select testing software



3. Write tasks and questions



4. Pilot test



5. Recruit participants



6. Analyze results

NN/g NNGROUP.COM

Figure 4.18: Steps of Unmoderated Usability Testing

Based on the article written by Whitenon, 2019, there are six steps of unmoderated usability testing which are visualised in Figure 4.18. The steps of this testing are defining the test goals, selecting testing software, writing tasks and questions, doing the pilot test, recruiting participants, and analysing the results. The first step of the test was already mentioned above, namely determining how high the potential of OER for teaching thematic mapping. Afterwards, the second step is to choose the testing software. In this research, we used ArcGIS Survey123 as the tool. The next step is to write the task and implement it in the questionnaires. Finally, the fifth step is to do the pilot test before publishing the tasks.

The pilot test was held on 26 July 2022, with one of the MSc Cartography students familiar with thematic mapping or cartography. The participant for this pilot test is a master's student, age 26, and contacted in personal communication. We held the test in a zoom meeting session, but our presence was invisible, and we only observed how the participant behaved during the pilot test. The participant did the task independently, was entirely focused, and took notes several times. The duration for the participant to complete the whole task is 32 minutes and 43 seconds. The participant submitted the pretest after 8 minutes 48 seconds and the post-test 23 minutes 55 seconds afterwards.

The sixth step of this usability testing is to recruit the participants. The targeted groups of the prototype users are students in several universities from different countries. In order to reach a wider audience, we frequently posted the user testing call on LinkedIn and Instagram. Furthermore, we sent the invitation through chat platforms i.e. Whatsapp and Telegram. Here is the list of user testing call publications:

1. The students taught by the experts involved in the expert interview session. The email is sent to 4 experts willing to forward the email to their students. All experts confirmed that they had forwarded the user testing call.
2. The students who are in the Thematic Cartography Class Whatsapp group. One of the experts allowed us to announce the call in the group. The call was posted in the group.
3. The students in ITC - the University of Twente who are in personal communication with us.
4. The Cartography and Remote Sensing program students at Gadjah Mada University who are in their 4th semester, 6th semester and 8th semester.
5. The MSc Cartography students, the 10th and 11th intakes.
6. LinkedIn platform post, which visualised in Figure 4.19. Moreover, we reshared the post on the Twitter and Instagram social media platforms. We invited non-student participants to gain more insight for the professionals about the prototype.

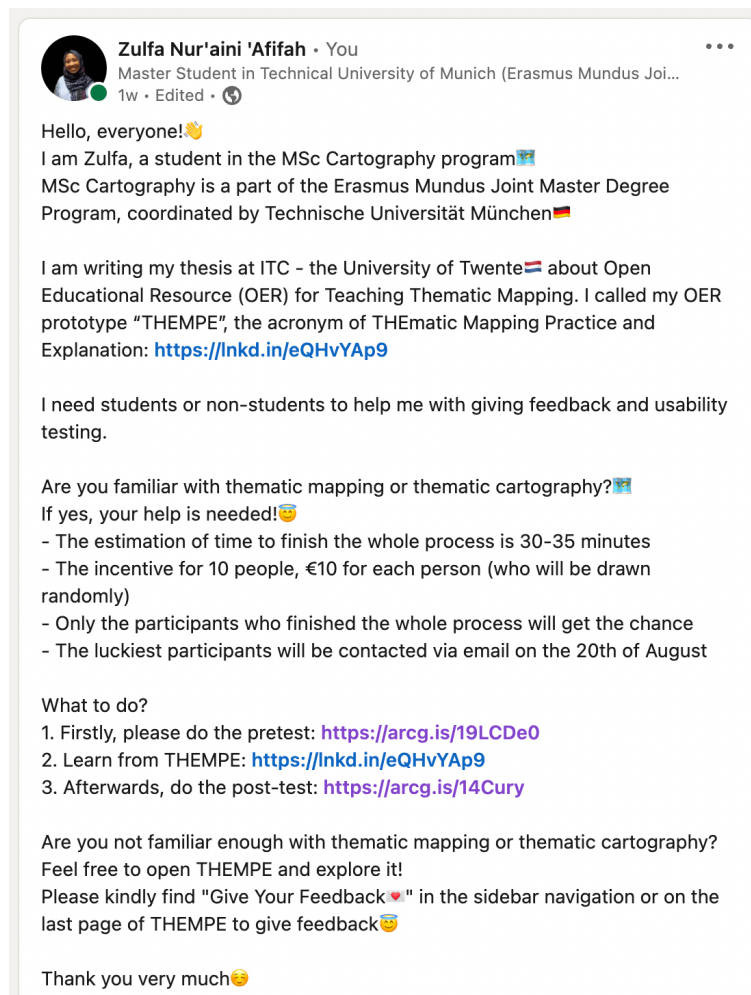


Figure 4.19: LinkedIn Post

For several weeks, we shared the user testing call until we got sufficient responses from the users. Thus, the last step of the test is analysing the result. Detailed result analysis will be given in the next section entitled "Chapter 5 - Result Interpretation".

4.4.2 The relevance of Open Educational Resources Prototype

As stated in the previous section, the prototype implementation is based on expert interviews, and syllabus and teaching materials review. The input from expert interviews and syllabus and teaching materials review inspired the contents and design of the prototype. However, in the actual implementation or the execution, there might be some distortion in how we projected the baseline into THEMPE as an OER prototype. Therefore, the evaluation to check the relevance of the prototype is necessary for this research. In order to achieve maximum evaluation results, we provided all the proof that the baseline had been successfully implemented in the prototype.

Chapter 5

Results Interpretation

This chapter discusses the result interpretation about potential and relevance as the final research question of this research. The interpretation of the results is explained and discussed in detail.

5.1 THE POTENTIAL OF OPEN EDUCATIONAL RESOURCES PROTOTYPE

The evaluation for this prototype is called usability testing or often mentioned as user testing. As mentioned in the previous section above, the higher the usability, the higher the potential of the prototype for teaching thematic mapping or cartography. We explained the usability of THEMPE in 3 terms: effectiveness, efficiency and satisfaction. We are eager to discuss each term in detail, along with the result interpretation and visualisation of the statistics obtained.

Firstly, we need to mention that the users are students and non-students. Therefore, we include the student group as the primary target group of users. Meanwhile, we consider non-student participants as potential users who are most probably familiar with thematic mapping in their jobs. The non-student users are essential since they allowed us to see the potential of OER to teach wider audiences enthusiastic about learning more about thematic mapping as a hard skill. In order to present user testing results, we divided the statistics and results into the students-only and all participants (including non-student users) for some cases. Afterwards, we attached the complete statistic visualisation for students and all participants in the appendix of this manuscript. We are eager to discuss the difference and see whether the result shows that THEMPE has the potential to teach all users, including non-student users, as high as the potential for teaching thematic mapping for students.

Fifty-six participants submitted the tasks, but eight uncompleted tasks were reported. Some participants who have not finished tasks are followed up by email. In the end, 48 completed and valid tasks are recognised as user testing records and can be analysed further. The statistics of the users can be seen in Figure 5.1 where master's student participants by 41.7% dominate it. Furthermore, the study program of the students varies, but the most significant share is the "Cartography" study program by 51.4% (18 students), as is shown in Figure 5.2. All participants come from different countries, meaning that the audience of THEMPE is broad as planned. The distribution of user testing participants is visualised in Figure 5.3.

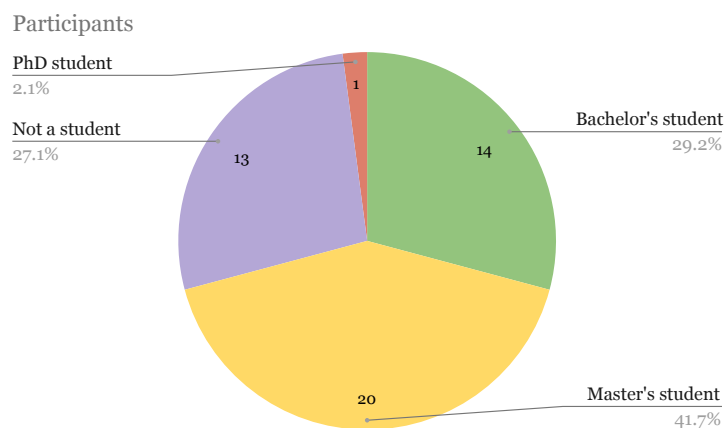


Figure 5.1: All User Participants

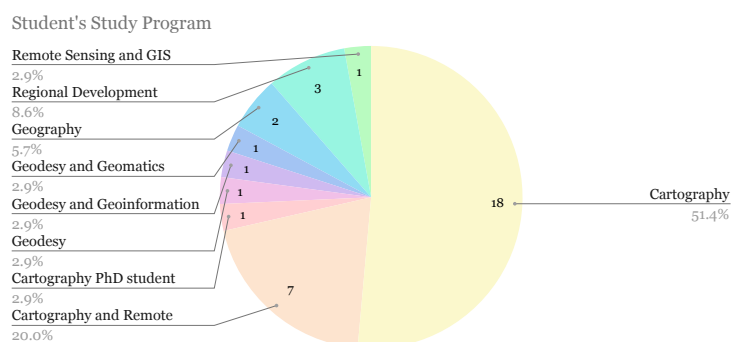


Figure 5.2: Students' Study Program

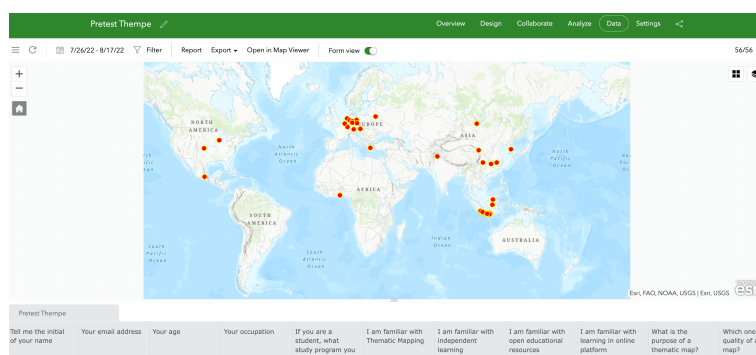


Figure 5.3: Map of Pretest Participants Distribution

5.1.1 Effectiveness

This section focuses on how the students can achieve the learning goals and how students can understand the materials. It is reflected by the completeness of the pretest and post-test. As mentioned above, there are 48 completed tasks out of 56 responses, so the completeness rate is 85.71%. This rate is sufficient for achieving the effectiveness goal. However, the participants who had not finished the tasks did not confirm or clarify why. The possible reason is that the participants do not feel engaged with the user testing task and THEMPE or do not have time and are not interested in continuing the task.

Furthermore, the accuracy of the answers will be considered as well. This accuracy is based on the questions section in both questionnaires, where students should answer the question. There are 4 possibilities for this, i.e. correct in pretest and post-test, correct in pretest, correct in post-test, and wrong in pretest and post-test as shown in Figure 5.5 and Figure 5.4. The proportion of each possibility is similar for student-only participants and all participants.

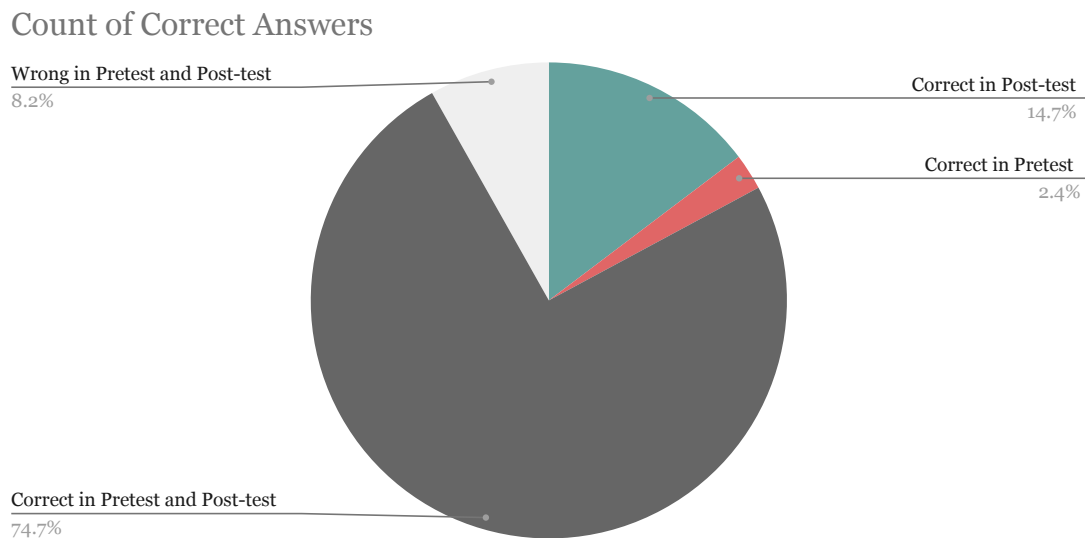


Figure 5.4: Count of Correct Answers (Students-only Participants)

Firstly, we looked into the first possibility, i.e. "correct in pretest and post-test". There are 74.7% and 70.8% of correct in pretest and post-test for student-only participants and all participants, respectively. It means that the questions are too easy for all participants. To prove the interpretation, it can be seen in Figure 5.6 and Figure 5.7 how easy the questions in the pretest and post-test are.

For the pretest, all participants strongly agreed and agreed by 2.1% and 52.1% respectively, that the pretest questions were easy. Meanwhile, for the post-test with the same questions or quizzes, there were 16.7% participants who strongly agreed, and 60.4% agreed that the post-test questions were easy. It is interesting how in the pretest, there are 2.1% and 6.3% participants strongly disagree and disagree, respectively, that the pretest questions are easy. Then, in the post-test, only 4.2% of participants think that post-test quizzes are difficult. It means that after learning from THEMPE, the participant's ability to answer the question increased. The other possibility would

Count of Correct Answers

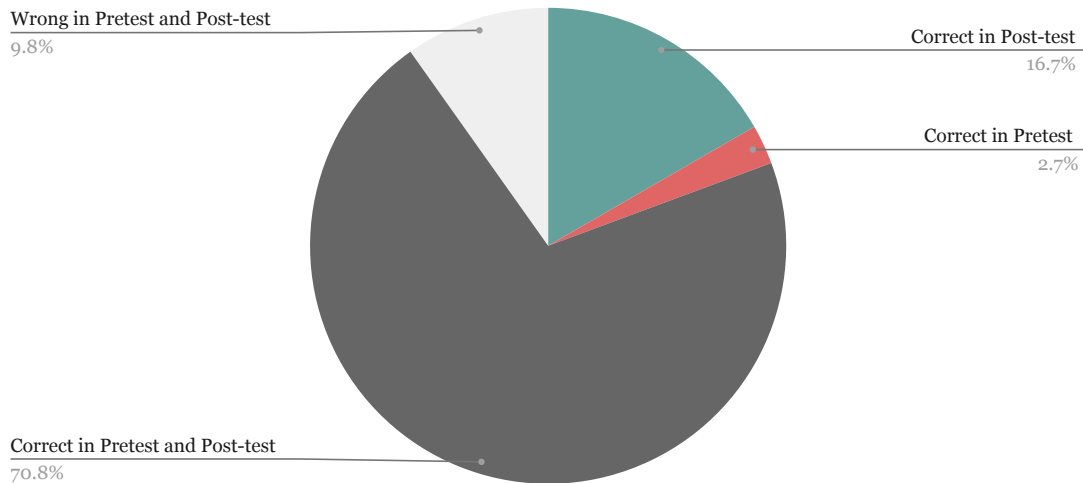


Figure 5.5: Count of Correct Answers (All Participants)

be that the participants are already familiar with thematic mapping, so they do not learn new things from THEMPE. Another proof is how all participants feel more confident in answering the post-test and the pretest. The comparison shown in Figure 5.8 and Figure 5.9.

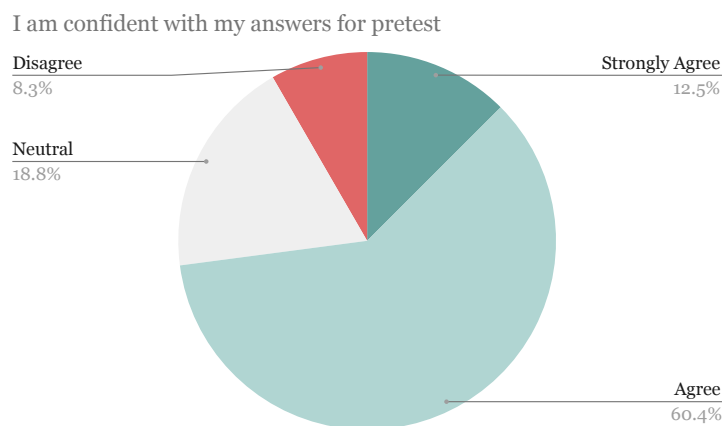


Figure 5.8: How All Participants Think About Pretest Questions

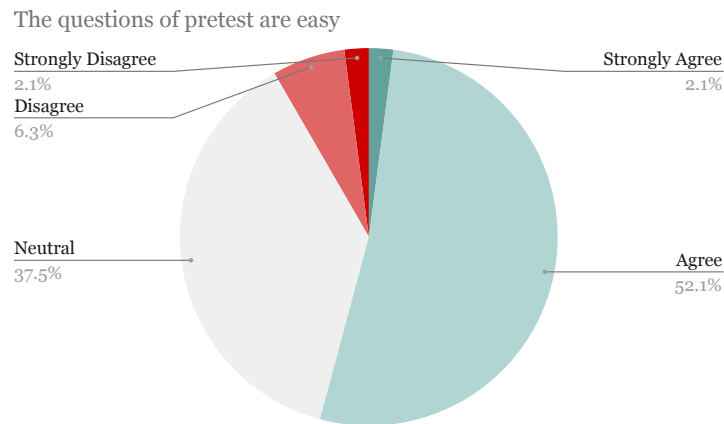


Figure 5.6: How All Participants Think About Pretest Questions

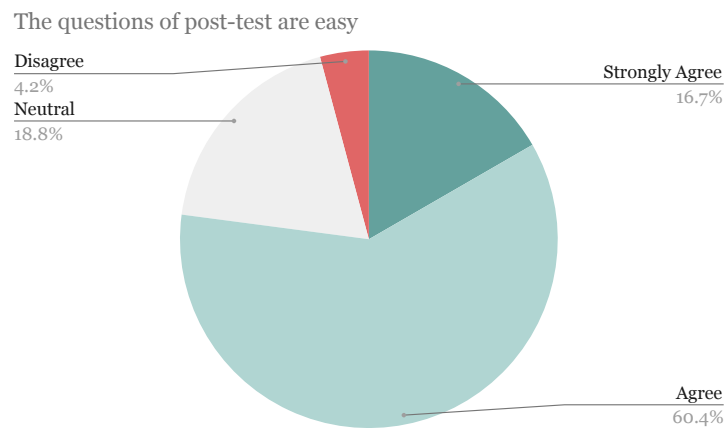


Figure 5.7: How All Participants Think About Post-test Questions

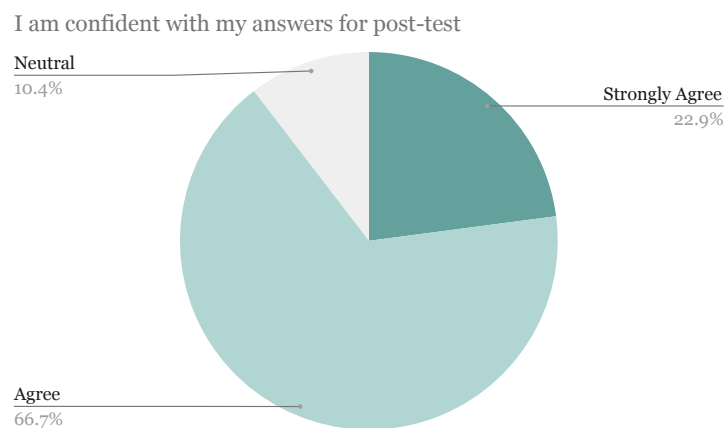


Figure 5.9: How All Participants Think About Post-test Questions

The next possibility is "wrong in the pretest and post-test". The proportion of participants who wrongly answered in the pretest and post-test by 8.2% for students and 9.8% for all participants. These shares show that the questions are too difficult. However, this interpretation is not valid since the proportion is considerably lower than the proportion of correct answers in both tests. Therefore, the other interpretation is that participants are not familiar with thematic mapping, and THEMPE does not provide a clear enough explanation, so they can not understand. Another possibility is that the participants are unfamiliar with thematic mapping but do not learn new things from THEMPE.

Generally, there is a wide disparity between the count of correct answers in the pretest and correct answers in the post-test for students and all participants. The proportion of correct answers in pretest means THEMPE give them unclear information or explanation and confuses the participants. Meanwhile, the correct answers in the post-test mean that participants learned something new from THEMPE and THEMPE successfully provided them with a clear explanation and examples. The "correct in post-test" number in all participants pie chart is higher than student-only participants. It proved that non-students could comprehend more from the prototype about thematic mapping.

The quizzes given to the participants consist of seven questions about thematic mapping. We include the quizzes in THEMPE as the game for unlocking further teaching materials. From these questions, we could see whether the students or the users managed to achieve the learning goals or not. Most of the questions are easy for the users since they can answer correctly in the pretest and post-test. Nonetheless, there are two questions which essential to discuss.

The first question is "What visual variable is suitable for representing Population Density data on a thematic map?" where the correct answer is "Colour value or Size". Population density data is quantitative data and has order or quantitative perception properties. The result for student-only and all participants are similar, visualised in Figure 5.10 and Figure 5.11. There are 18.2% and 23.9% wrong answers in the pretest and post-test for students and all participants, respectively.

This result shows that THEMPE is not providing an excellent explanation to make them understand the material about visual variables and perception properties. Moreover, some of the participants are not able to learn something new. However, the correct answers proportion in the post-test is significantly higher for both cases, 36.4% for students and 37.0% for all participants. From this percentage, we can conclude that THEMPE can give more explanation to make them understand after the learning process and answer correctly in the post-test quizzes.

What visual variable are the best for representing Population Density data on a thematic map?

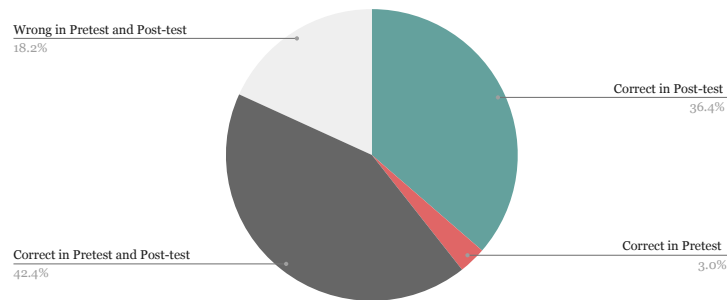


Figure 5.10: Question 3 Answers from Student Participants

What visual variable are the best for representing Population Density data on a thematic map?

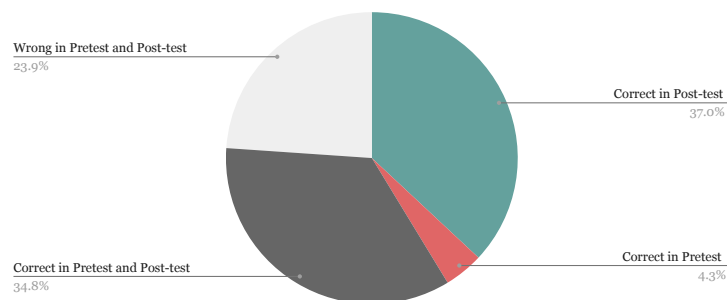


Figure 5.11: Question 3 Answers from All Participants

On the other hand, the next question, "Which visual variables can be used to visualise data with a Flow Map?" shows the opposite result of the previous question. The answer to this question is "colour hue, size, colour value" since a flow map can represent both quantitative and qualitative data. According to Figure 5.12 and Figure 5.13, the proportion of wrong answers in pretest and post-test is higher than correct answers in post-test for both students and all participants. All participants have more percentage of 1.9% since the non-students probably have less ability to understand the materials than the students. From this result, we could reckon that the material about flow maps is poorly explained and misunderstood by the users. The users think that the visual variable "orientation" is similar to the "flow direction" of a flow map. The possible solution to tackle this problem is to provide one section explaining the difference between "orientation" and "flow direction" in future work. Despite this issue, from the interpretation beforehand, it can be concluded that THEMPE had successfully achieved the effectiveness goal.

Which visual variables can be used to visualize data with a Flow Map?

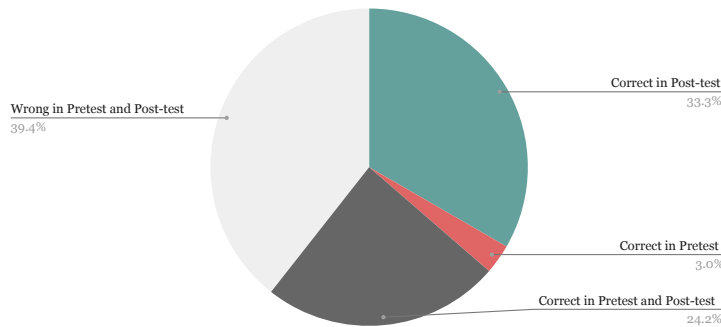


Figure 5.12: Question 6 Answers from Student Participants

Which visual variables can be used to visualize data with a Flow Map?

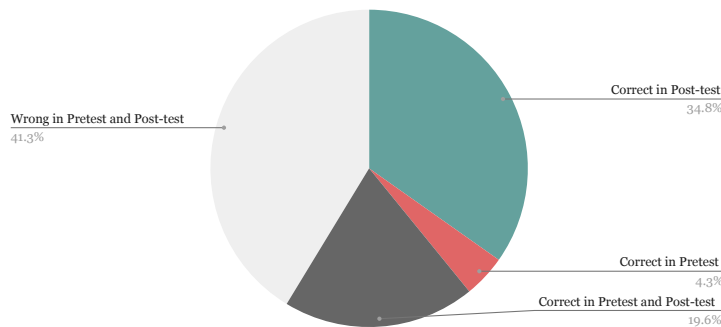


Figure 5.13: Question 6 Answers from All Participants

5.1.2 Efficiency

In the previous chapter, we explained efficiency based on the ISO 9241-11 (ISO, 2018); efficiency means how sufficiently the resources are used regarding the results achieved. Efficiency in this research is strongly related to how well the overall product can achieve the goal with its resources. Therefore, this section focuses on how the THEMPE features work as what it is supposed to be. We are eager to see how the side navigation bar helps to see the learning path, the quiz helps to understand the materials to answer pretest & post-test questions, and the practice part helps the students to perceive the given materials. Moreover, the questions are given in the form of ratings and the Likert scale to validate the expectation of OER advantages.

Firstly, we need to discuss the duration needed by the participants to complete the learning process in THEMPE. Figure 5.14 and Figure 5.15 represent that most of the participants finished the learning process in THEMPE between 16-30 minutes long. It shows that in the chart for all participants, there are participants who finished the learning process in more than 60 minutes, which means that non-student users need more time to study thematic mapping from the prototype.

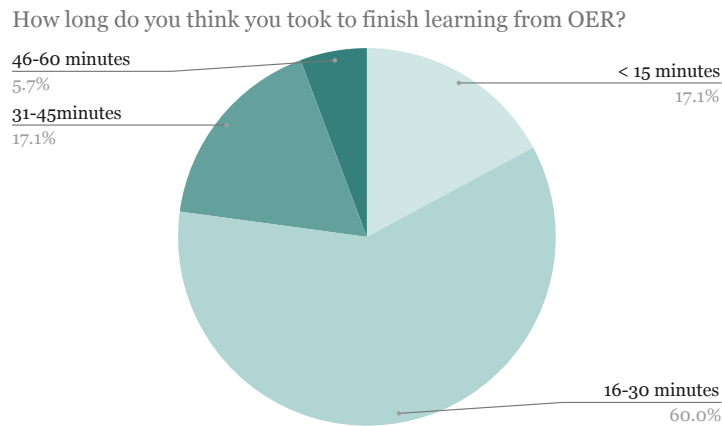


Figure 5.14: How Long Students Finished Learning Process

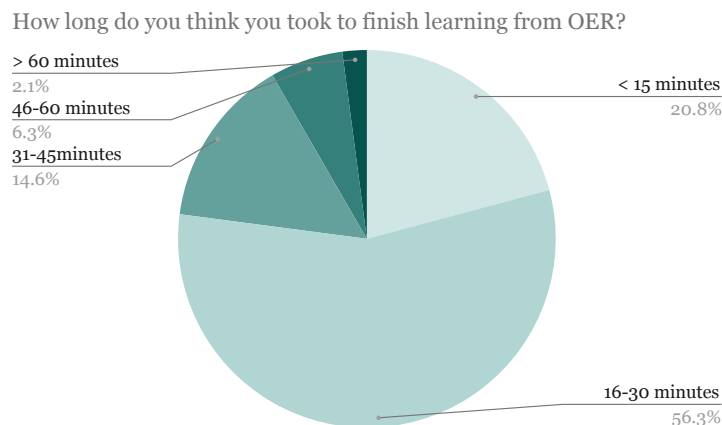


Figure 5.15: How Long All Participants Finished Learning Process

In order to validate the advantages of OER, we designed the questions regarding the OER in the Likert scale form. According to the result, there is no considerable difference between students and all participants, so we only discuss the result for all participants. Figure 5.16, Figure 5.17, and Figure 5.18 show us that most of the participants are agree with the advantages of THEMPE as an OER for teaching thematic mapping or cartography.

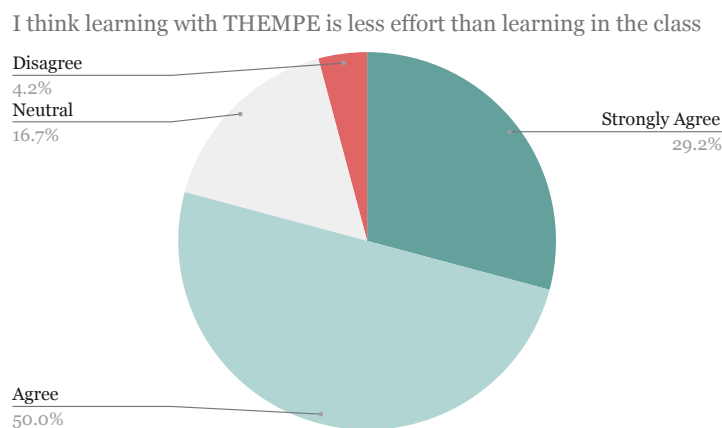


Figure 5.16: What All Participants Think About The First Advantage

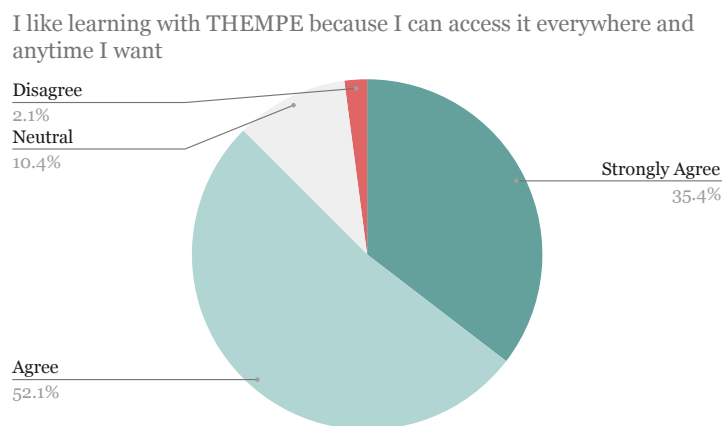


Figure 5.17: What All Participants Think About The Second Advantage

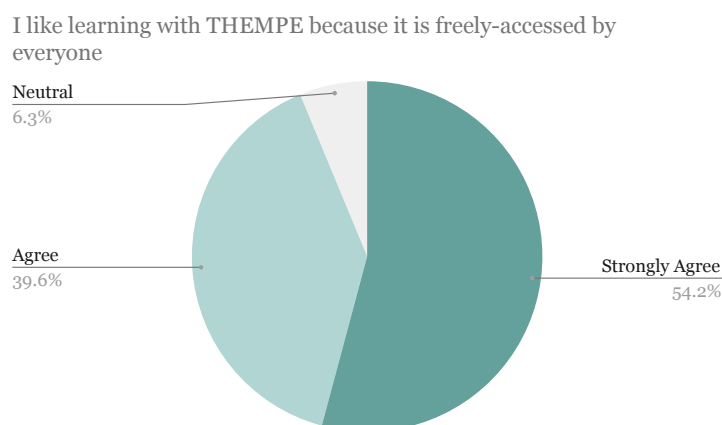


Figure 5.18: What All Participants Think About The Third Advantage

Furthermore, for checking how the users feel about how THEMPE features work, another Likert scale question type is asked, i.e. "I feel lock-unlock with the quiz can keep me excited learning from THEMPE" and "I feel more engaged with THEMPE as a teaching tool". Figure 5.19 and Figure 5.20 visualize how the participants agree with the statements. From this result, it could be concluded that the OER meets the expected advantages and achieve efficiency goals.

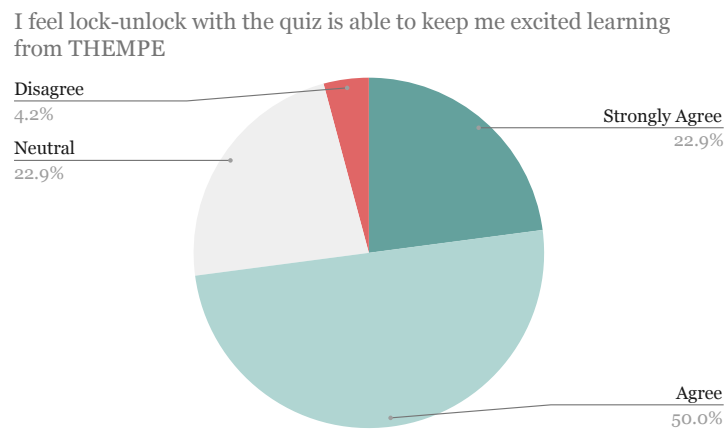


Figure 5.19: What All Participants Think About The First Statement

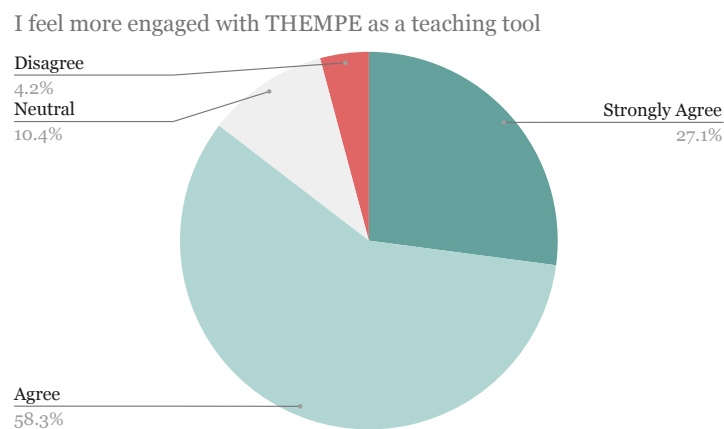


Figure 5.20: What All Participants Think About The Second Statement

5.1.3 Satisfaction

We explained in the previous chapter that based on ISO 9241-11 (ISO, 2018), satisfaction in this context means the user's physical, cognitive, and emotional results from using the system, product, or service fulfil the user's necessities and expectations. Hence, this section discusses how good the feedback from user testing participants as the users is. The most important information to get is how they think about THEMPE design in general, the materials in THEMPE, the gamification implemented in THEMPE, what they like the most, and what can be improved in THEMPE.

The question type is in the form of a rating and ranking. Firstly, the average rating for each aspect rated by students is in Figure 5.21, then the one rated by all participants is in Figure 5.22. Both charts show the difference in the top aspect rated by students and all participants. For student participants, they rated the exercise part as the highest average rating, which is 4.71. Meanwhile, all participants' average rating is different, and the highest average rating is for the materials. This circumstance is possible since the students play more to gain more hard skills, while non-student users prefer to have a better quality of materials to provide them with valuable lessons. From the satisfaction evaluation, we could conclude that we had successfully reached satisfaction goals, like how effectiveness and efficiency goals were reached. Hence, THEMPE has a high potential for teaching thematic mapping.

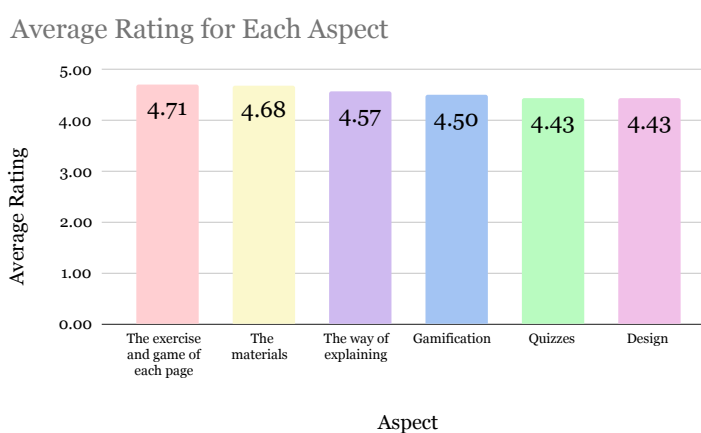


Figure 5.21: Rating Average for Each Aspect Given by Students

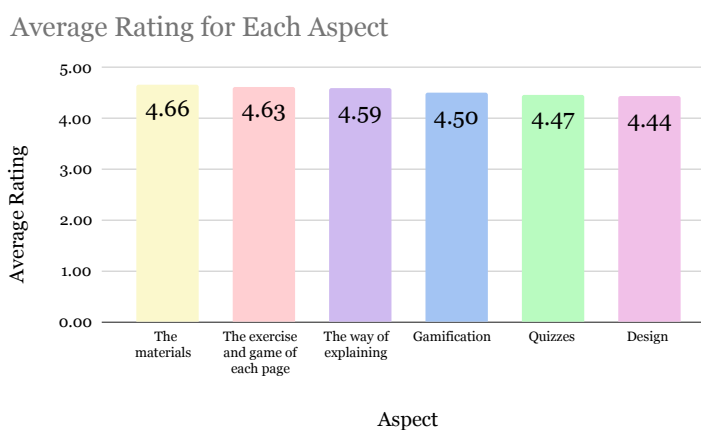


Figure 5.22: Rating Average for Each Aspect Given by All Participants

5.2 THE RELEVANCE OF OPEN EDUCATIONAL RESOURCES PROTOTYPE

THEMPE has been built based on expert interviews and syllabus review input. We might misunderstand several inputs. Therefore, the evaluation to determine the relevance of the prototype is required in this research. The proof that baselines have been successfully implemented in the prototype will be given along with the interpretation below.

5.2.1 How expert interviews input implemented in the prototype

The expert interviews were based on the questions asked in the interview. There are questions that the experts answered with a similar response. Thus, it is easier for us to find the pattern of the teaching method used by the experts. For instance, the answer to the question "What is the most important thing you emphasise in your class? The concept behind thematic mapping or the technique of thematic mapping?" where the experts answer similarly. Here is the list of how the input of this expert interview had been successfully implemented in the prototype:

1. The answer to the question "What is the most important thing you emphasise in your class? The concept behind thematic mapping or the technique of thematic mapping?" which informs the most important in the class:

The experts mention that the concept behind thematic cartography or thematic mapping and the application of techniques is important. In addition, good map examples are essential to show the students in the learning process. Hence, the implementation in the prototype can be seen in Figure 5.23 how all the pages in THEMPE provide the explanation & practice part.

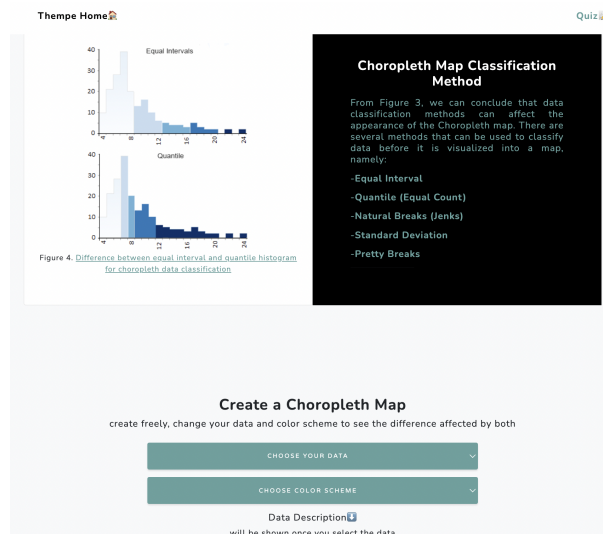


Figure 5.23: Example of how THEMPE has explanation and practice part

2. The answer to the question "What is the main learning objective of the thematic mapping class you teach?" which informs the main objectives or outcome:
 - Understand the whole process of creating a thematic map

- Understand the whole process of how to do thematic mapping
- Understand design maps, produce maps, and critique maps
- Understand basic skills in geodata processing, the selection and application of graphic design tools and the cartographic processing of map content.
- Understand the fundamental concepts of thematic cartography. They can analyse and visualise geodata. Furthermore, to allocate graphic variables to data scales and apply visualisation methods.
- Understand about visualising the data into a map and judging the design from a map.

Thus, THEMPE provides the contents to achieve the learning goals even though it is not as complete as the whole teaching materials. On the other hand, THEMPE as an OER prototype only includes the small part since it is designed and arranged in a short time. Hence it is focused on the common map types. The overall contents can be seen in Figure 5.24, which is the locked sidebar navigation.

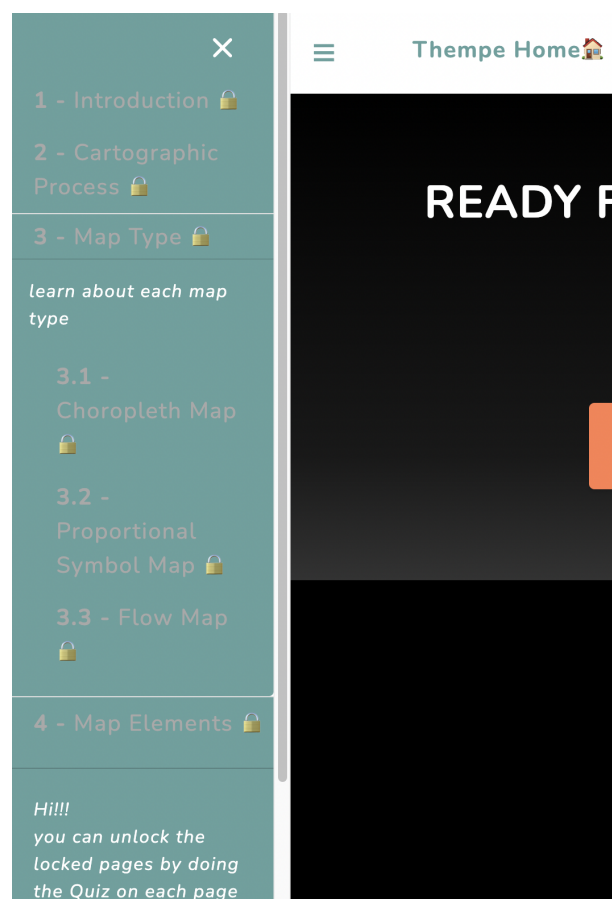


Figure 5.24: THEMPE contents in the sidebar navigation

3. The answer to the question "Have you ever used a tool for supporting your class? For example, an online tool for creating a map or software for automatically generating a map", which informs the tool for teaching:

The teachers answered that they prefer to introduce GIS software to their students. In addition, they also provide a tool which contains online resources that the students can access

to it easily. It is implemented in THEMPE as the introduction to the example of mapping software that can be seen in Figure 5.25.

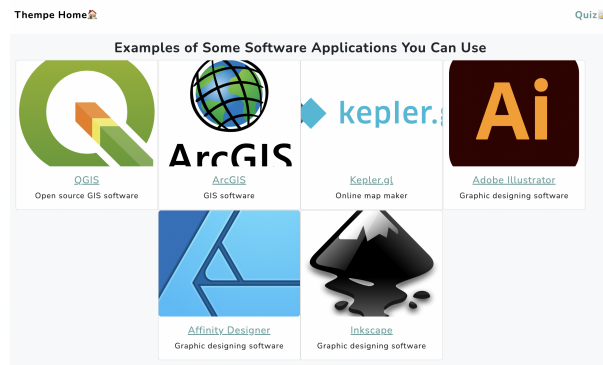


Figure 5.25: Example of software can be used for mapping

4. The answer to the question, "What kind of OER that can support teaching thematic mapping do you expect?" where all educators have different expectations from one another, provided valuable inspiration for us. The following is how we implemented some of the educators' expectations in the prototype in a short time:
 - The expectation of interviewee 2 is that OER can explain the data scale, the characteristics of visual variables, the thematic map types they can choose and the elements of the map layout. It is implemented in THEMPE contents as shown in Figure 5.26 and Figure 5.27.

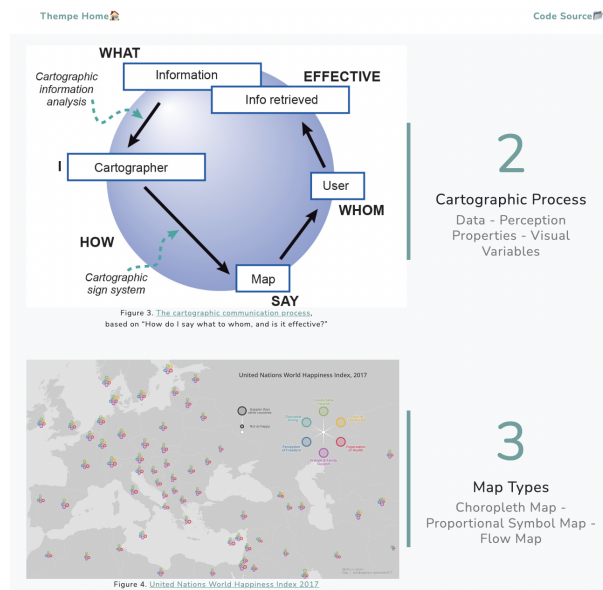


Figure 5.26: THEMPE provides Cartographic Process and Map Types explanations

- The expectation of interviewee 3 and interviewee 6 is that OER should have a learning path because it is important to make sure that the students can understand the material, OER provides many good map examples and OER which is open for everyone to

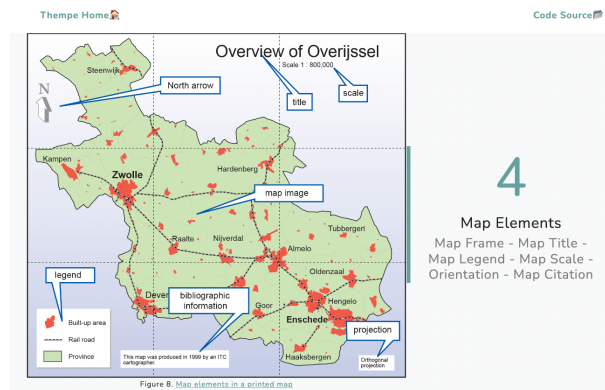


Figure 5.27: THEMPE provides Map Element explanation

contribute (this one will take OER to the next level). The learning path can be seen in Figure 5.28 and in THEMPE home page. All the contents are still locked and can be unlocked after the students complete the learning process on a certain page by doing the quiz on each page. It is related to the next expectation of another interviewee.

Furthermore, the part where good map examples are included in the "Introduction" page as shown in Figure 5.29. This prototype is available in the public domain and published on GitHub. Finally, the users can see the "Code Source" in the upper right corner of THEMPE home page, as can be seen in Figure 5.30.

- The expectation of interviewee 4 is that the OER can be slightly gamified to keep the students interested in the materials. Thus, as mentioned in the previous expectation by other interviewees, THEMPE provides lock-unlock features. Therefore, the further materials can only be unlocked by completing the learning process on the previous page and doing the quiz on each page. For instance, the quiz on the Introduction page is shown in Figure 5.31.

Furthermore, interviewee 4 expects a narrative OER, which also provides keywords in bold, so the students are more attentive to the important information. We implemented it in THEMPE as a narrative way of explaining. The explanation in THEMPE is simplified as much as possible since we assumed that the students are not native English speakers. We purposely explain it this way to allow the students to understand it better. The learning path from the beginning to the ending of THEMPE are connected as can be seen in Figure 5.32 as the beginning of THEMPE and Figure 5.33 as the ending of THEMPE. In addition, the keywords are typed in bold text as shown in Figure 5.34 to make the students more attentive to the essential information.

From the explanation above, we concluded that the input from expert interviews had been successfully implemented in THEMPE as an OER prototype.

5.2.2 How syllabus and teaching materials review result implemented in the prototype

The learning objectives or outcomes of teaching thematic mapping in universities for bachelor's and master's students are the guidelines for educators to arrange and design the syllabus and teaching materials. Next, the materials are reviewed to answer the previous research question. Finally,

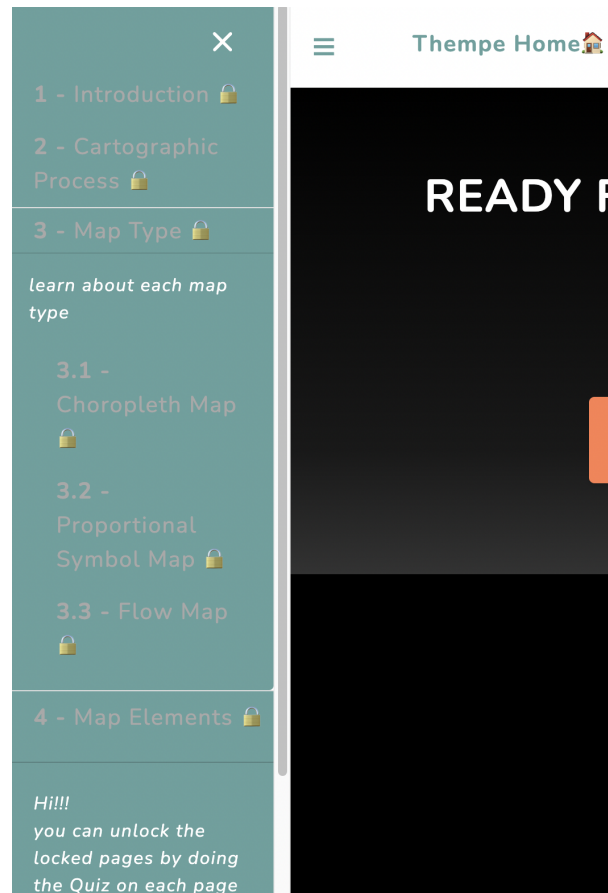


Figure 5.28: THEMPE contents in the sidebar navigation

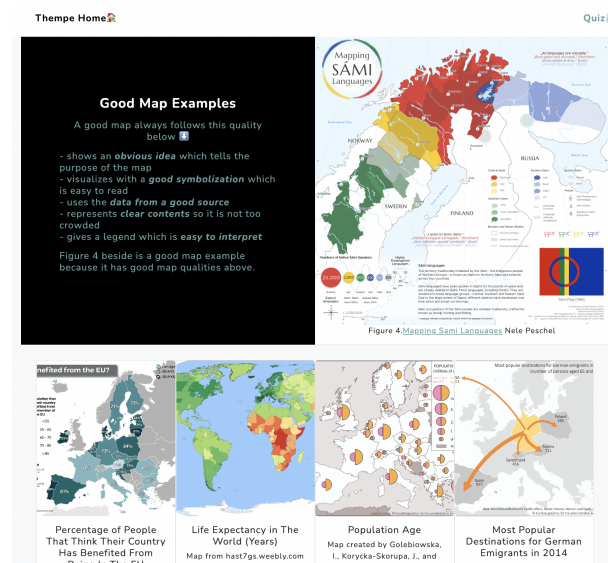


Figure 5.29: Good map examples part in Introduction page

Code Source

Figure 5.30: Code Source button in THEMPE Home page

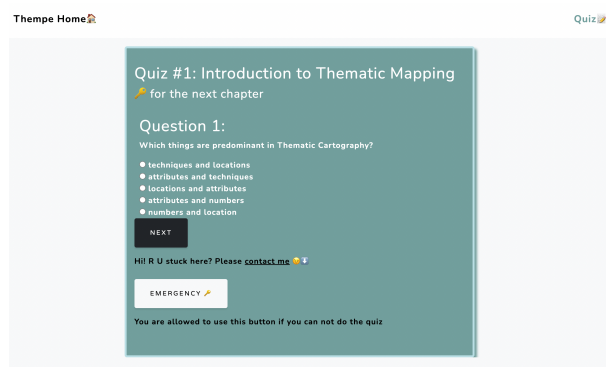


Figure 5.31: Quiz for Introduction page

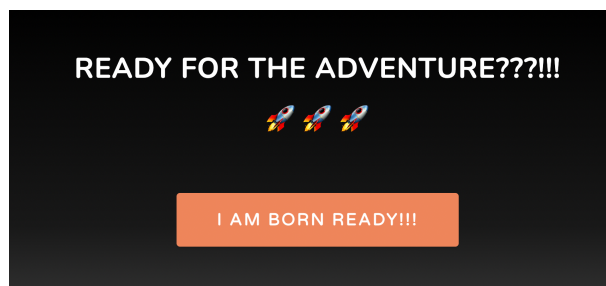


Figure 5.32: In the last part of THEMPE Home page

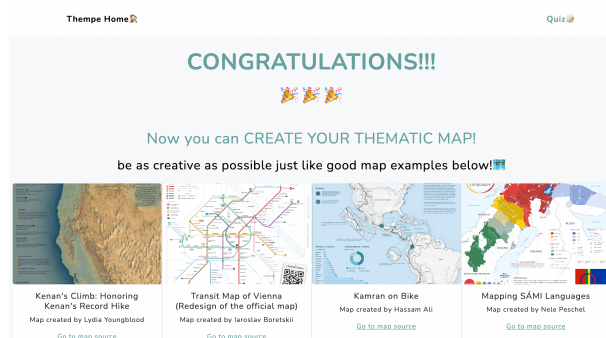


Figure 5.33: In the last part of Map Element page

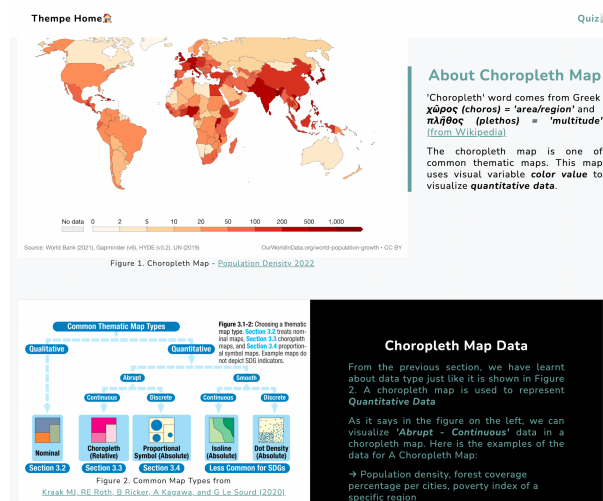


Figure 5.34: How some of the most important keywords typed in bold

the evaluation must check how this is implemented in the prototype. Below is the list of how bachelor's and master's learning topics are included as the prototype contents:

Bachelor's teaching materials

- Introduction to cartography: included in Introduction page but specified to the introduction to thematic mapping
- Data types: included in Cartographic Process page
- Visual variables: included in Cartographic Process page
- Thematic visualisation techniques: included in Map Type pages, i.e. Choropleth Map, Proportional Symbol Map, and Flow Map
- Layouting: included in Map Element page

Master's teaching materials

- Introduction to cartography: included in Introduction page but specified to the introduction to thematic mapping
- Cartographic process and the visualisation process: included in Cartographic Process page
- Perception properties: included in Cartographic Process page
- Visual variables: included in Cartographic Process page
- How to map quantitative: included in Map Type pages, i.e. Choropleth Map, Proportional Symbol Map, and Flow Map
- Putting it all together (Hierarchy and layout): included in Map Element page

Chapter 6

Discussion

This chapter recaps the conclusion of the whole research and mentions the limitations. Future development and research will be discussed in this chapter as well.

6.1 CONCLUSION

6.1.1 Teaching Thematic Mapping in Universities - RQ1A

From the expert interviews to answer RQ1A, the existing method of teaching thematic mapping can be revealed and then used to find patterns in teaching among all educators. The result of the expert interview states that the essential things in the class are the theory behind thematic mapping or cartography and the application of techniques in a thematic map-creating process. Furthermore, the class consists of lecture sessions and practice/exercise sessions, so active learning is the most preferable. It enables the students to be involved more and develop their hard skills for thematic mapping. The educators mentioned that in-class teaching is preferable, but online teaching is possible and can be more effective by increasing student engagement.

6.1.2 Syllabus for Bachelor's and Master's Students - RQ1B

Syllabus and teaching materials reviews as the answer for RQ1B have shown that what educators teach in the classroom overlap. What is meant by overlap here is that the material for bachelor's and master's students has similarities for several topics. This similarity is then used as a content outline for the prototype. For example, the same topic for both levels of education is an introduction to what thematic mapping is, the cartographic process, an introduction to the types of maps, and how to arrange map elements in a map layout. Hence, we can conclude that there are not many differences in teaching thematic mapping for bachelor's and master's students.

6.1.3 Open Educational Resources Advantages and Developments - RQ2A

OER is a resource for teaching, learning and research that is publicly available for everyone under a special license. Therefore, it has excellent potential to reduce costs in the mission of improving the quality of education. Based on the literature review to answer RQ2A, three main advantages of OER, namely less cost, can be accessed by everyone from everywhere, and available for some

people to use or reuse OER under a specific license. The development of OER started in the late 1990s, and currently, more OER is available for the students to learn, especially for cartography and GIS.

6.1.4 Prototype Implementation - RQ2B

The prototype implementation was done to answer RQ2B, based on expert interviews and syllabus and teaching materials review. The input from the experts inspires the contents and design of the prototype. Furthermore, the teaching materials enrich the idea of the contents for OER prototype as well. Finally, the prototype implementation is realised using Vega-lite, especially for practice or exercises, and Bootstrap for the overall responsive web design.

6.1.5 Evaluation for Prototype - RQ3A

The answer for RQ3A has been discussed to evaluate the potential and relevance of THEMPE for teaching thematic mapping. The assessment for effectiveness, efficiency, and satisfaction reflects the potential of THEMPE as a teaching tool. Based on the evaluation result, THEMPE has achieved the goal for effectiveness, efficiency, and satisfaction. Therefore, it could be concluded that THEMPE has excellent potential for teaching thematic mapping. Furthermore, relevance evaluation is based on how the expert interviews input and syllabus/teaching materials review implemented in THEMPE. This evaluation showed that THEMPE has high relevance for teaching thematic mapping.

6.2 LIMITATIONS OF OPEN EDUCATIONAL RESOURCES PROTOTYPE

The implementation of OER as THEMPE has achieved high potential and relevance. THEMPE managed to get good feedback from the users. Here is the list of users' feedback examples on THEMPE written in the post-test of the user testing task:

- *I like the well-chosen figures (maps) along with the short and precise explanations at the side. Everything is well cited with links which allows to explore the source better in case you want to know more about a specific topic. Also, I like The whole setup including the ramifications which keeps the user engaged to learn.*
- *What i like the most about THEMPE is the concept itself, which is so interesting and easy to understand. When i enter the website, i can recall what was learned during the thematic geography course and also practice my English skill.*
- *I LOVED the tone used and the smiley faces! I thought the presentation was really encouraging and fun! I know the purpose was to be a standalone education unit, but given that THEMPE is intended to be open access, I'd definitely send my students to review the module contents to practice for exams and to get extra help. It's really cool! I thought the color scheme was really appealing, and the interactivity / gamification was fun!*
- *I was really surprised when I opened THEMPE, it was beyond my expectations. I thought like most other free learning platforms where users can freely access random material, but it turned*

out to be very very very satisfying. The key feature for the material is to make it more enthusiastic to learn, so for example there are points that you don't understand, you can repeat them again until you really understand. Moreover, there is a quiz that is asked to group a variable into the correct group. That's so coooooool.

- *Thempe is a good platform to study thematic map. It feels like I am joining a full course of cartography. The materials are resourceful but can be explained in a clear way. The interactive parts and quizzes are addicting, haha. Good job Zulfa.*

Nevertheless, THEMPE still has several aspects for improvement. Until this stage, the lack of gamification is due to our limited programming skills. There is numerous feedback related to gamification. For instance:

- *Answered that earlier. In short, lock-unlock doesn't keep me hooked, but it's a start. Some plant that grows with progress or some Tamagochi-ripoff.*
- *If I have finished all the topics then I choose the first topic, then the other topics are locked again. If you want to return directly to the third material, you can't because you have to go through the second material first, so you have to repeat the second material even though you only want to repeat the third material. Maybe you can make a kind of checkpoint or a button to reset the material so that when we want to repeat the material we don't have to fill out the quiz again. Maybe that's also suggestion for the quiz, lots of questions are made but only 3 of the questions available in one topic appeared and appeared randomly so the questions didn't stay the same.*

THEMPE is an OER prototype; we plan to allow everyone to contribute, add materials, or make edits on it. The code source is included on the Home page. However, the design is too complicated for everyone to contribute, so it requires redesigning the whole prototype without losing the essential information.

6.3 ADVANTAGES AND DISADVANTAGES OF USER TESTING METHOD

In this research, we used "Remote Unmoderated Usability Testing". As elaborated in the previous chapter, we have done remote unmoderated usability testing since the targeted groups of users are students from different countries. In addition, we included the non-student users as optional participants so that we could gain more insight. This method allowed us to give the tasks to the potential participants on social media platforms or the internet. As a result, we successfully gained many participants from several countries to participate in the user testing. The advantages and disadvantages of this user testing method will be given below.

6.3.1 Advantages of Remote Unmoderated Usability Testing

- **This method enabled us to gain a wider audience.** We posted the user testing call on the internet, i.e. via LinkedIn and Instagram. Moreover, we asked the experts involved in the expert interviews via e-mail to contact their students to participate in the user testing. In addition, communication via Whatsapp allowed us to contact more people to participate.

- **A wider audience means more insights and feedback.** We obtained insights from non-students who are workers from several institutions. The feedback from participants is valuable to help us analyse the potential of THEMPE
- **This method allows participants to explore THEMPE freely while finishing the user testing task.** It was possible that since this method is unmoderated, we, as the researcher, could not disturb the user testing process.
- **As mentioned above, we did not need to moderate as the researcher.** It is more efficient in time for both parties. We did not need to make an appointment with the participants and vice versa.

6.3.2 Disadvantages of Remote Unmoderated Usability Testing

- **It is possible to get the uncompleted tasks since there is no control over the participants.** Some participants only finished the pretest, and afterwards, they were supposed to learn from THEMPE, then do the post-test. However, getting completed tasks from participants was not as easy as expected. Therefore, every time we noticed a pretest submission after 2 hours but no post-test was submitted from the same participant; we sent the follow-up e-mail to that participant. This method worked for some participants.
- **The other risk of this method is we could get the outliers and cheaters.** The outliers are participants who show the most different behaviour among all participants. They can be seen by sorting the answers from pretest and post-test answers. From this, we could not see any outliers who troubled the overall user testing result. Furthermore, we tried to identify the cheaters. The cheaters are participants who randomly answer questions or look at THEMPE materials while answering quizzes in pretest or post-test so they can answer everything correctly. To tackle this problem, we looked into answer distribution among the participants. We expect to be able to see that the participants are cheating by having all questions correct or showing random answers pattern. As a result, we can see no cheating indication in our user testing.
- **There is the possibility of having poor result quality.** It can happen if we do not have a sufficient number of participants to do the user testing, mainly because this is summertime when everyone is having their vacations. The unusual pattern could lead us to poor analysis for OER prototype potential. We successfully solved the problem by giving enough time to share user testing calls worldwide on the internet. The questionnaires were open for 3-4 weeks since the published user testing call. For this user testing method, the sufficient number of participants is more than 30, and we managed to reach 56 participants. We could see the pattern from the user testing result and managed to analyse the result satisfactorily. As a result, we reported excellent results from user testing. Hence, we could conclude that we successfully tackled the disadvantages of this method.

6.4 FUTURE DEVELOPMENT AND RESEARCH

Based on the limitation above, we need to think about how to tackle the lack of gamification. Gamification can be improved by improving the creator's programming skills. Another solution is to involve a programmer and collaborate with the interdisciplinary team. People willing to improve

the gamification are welcome to contribute from the available GitHub repositories. Furthermore, the possible solution regarding the design can be tackled by allocating more time to the designing part. Involving the user experience expert will be the best solution for this issue. Apart from these, feedback from the user testing allowed us to see the possible development in the future. For example:

- **Including more language** in the THEMPE based on these feedbacks:

- *Of my own what needs to be improved from Thempe is a variation of the language used (if possible).*
- *It would be great if Thempe could be accessed in multiple languages besides English so it could widen the participant's interest*

- **Improving the quizzes quality** on each page based on this feedback:

Some pretest Questions were vague. Example: design guidelines vary within a particular thematic map type or subset (there are MANY ways to represent population density, e.g. heat map, dot density, choropleth). I didn't know which map type I was being asked about. That might not be a problem for novices though, since they won't know lots of map types. Also, I consider orientation a flow map variable because direction serves a critical communication function on flow maps. (orientation is technically not chosen by the cartographer, so not everyone will agree it's a 'variable' in this case.) The section asking the user to sort by visual variable use was confusing because many belonged to more than one category (e.g., selective and quantitative). But by sorting into one category, the activity implied that the variable was only correctly used in one way when this is not the case. Some Questions I didn't understand. Overall, the module will benefit from more proofreading and novice testing.

- **Adding more contents and multimedia** based on these feedbacks:

- *maybe we can add another thematic material or another theme for the map, but it need more data*
- *In my opinion, thempe can be very helpful in understanding the material, maybe more explanation can be added about the charts/diagrams*
- *maybe with some video animation will make the thempe more perfect*
- *Add video*
- *make more visualisation like a video*

As discussed above, THEMPE achieved high potential and relevance for teaching thematic mapping. In future work, it would be possible to create a similar prototype with the same or even better features OER to teach Cartography as a whole or other subjects. The gamification can keep students interested in continuing independent learning and gaining hard skills from the exercise parts. Furthermore, the implementation of similar OER features as THEMPE allows to teach more knowledge, especially related to gaining hard skills.

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Appendix A

Expert Interviews-related Documentations

A.1 EXPERT INTERVIEW TERM OF REFERENCE

Introduction

1. Name of researcher: Zulfa Nuraini Afifah
2. Title of the research: Open Educational Resources for Teaching Thematic Mapping
3. About the research: Cartography is making maps, and maps are a part of cartography. As defined by the International Cartographic Association (ICA) below: "Cartography is the discipline dealing with the art, science and technology of making and using maps." This study will focus more on cartography as a technique, especially in the thematic cartography domain. First, thematic cartography is closely related to the observed and extracted attributes. After that, techniques and attributes are dominant and will eventually produce a thematic map as the product. Finally, as is well known, thematic cartography will focus more on how one can produce maps with specific techniques as hard skills. Hard skill is an ability obtained through repetition, practice, and education. Education is necessary to provide the abilities described above and plays an important role. On the page owned by this forum (<https://education.icaci.org/education-material/>), there are several educational materials in the form of literature or textbooks, valuable online resources for Cartography and Geographic Information System (GIS) theory and tutorials, and other structures to provide knowledge to others who want to learn cartography. This shows us that learning about cartography can be done through various methods. This study will focus on the thematic cartography teaching given to university students. This learning is usually carried out using traditional methods, namely through textbooks or also delivering material in class in thematic cartography courses. As one of the hard skills that students must possess, this is where students have to do many exercises to gain and strengthen their abilities in thematic mapping. Open Educational Resources, or after this referred to as OER, can be defined as teaching, learning, and research resources that are in the public domain or have been released under an intellectual property license that permits their free use or reuse by others (Marcus-Quinn & Diggins, 2013). Based on this definition, it can be seen that OER can be a potential tool that can be used in teaching thematic cartography. This OER can be shared with students more efficiently and easily accessed. Students need easy access to learning materials and must practice as much as possible to master thematic mapping. However, no OER has implemented a syllabus for teaching thematic cartography. So in this research, we want to make an OER prototype that can be used by bachelor's and master's students. After the implementation of thematic cartography, teaching materials are applied in the OER, and it is

also necessary to evaluate the prototype. This evaluation aims to see how high the potential of OER as a new tool in teaching thematic cartography is. The potential mentioned here means how OER can be one of the methods for teaching thematic cartography to achieve learning goals. In addition, we will learn how the syllabus and curricula have been implemented in the universities where our target groups study thematic cartography. After that, we will look at the relevance of our OER content to what these students are learning. From this, we expect that we can determine the potential and the relevance of OER in teaching thematic cartography curricula.

Technical guide for interview

1. What? This interview is about the method that you, as the teacher, use for teaching thematic mapping or thematic cartography
2. When? The interview will be held on the educator's preferred date and time as the source. The duration of this interview is 35-45 minutes
3. Where? This interview will be an online interview at a zoom link which will be shared the day before the interview is conducted as a reminder.
4. How? After the educator accepts the interview request, the appointment will be arranged. The researcher will lead the interview, asking the question which will be explained in the next section. The interview will be audio-recorded as the interview documentation, but only if it is allowed by the interviewees.

About Open Educational Resources What is Open Educational Resources (OER)?

Marcus- Quinn & Diggins (2013) defined Open Educational Resources as teaching, learning, and research resources in the public domain or have been released under an intellectual property license that permits their free use or reuse by others. The examples of existing OER:

1. Thematic Map Tutor by Barend Köbben (<https://kartoweb.itc.nl/TMT/>)
2. Symbolisation and the Visual Variables by White, T. (<https://gistbok.ucgis.org/bok-topics/symbolization-and-visual-variables>)
3. Common Thematic Map Types by Golebiowska, I., Korycka-Skorupa, J., and Slomska-Przech, K (<https://gistbok.ucgis.org/bok-topics/common-thematic-map-types>)

List of topics asked in the interview

1. Students who join your thematic mapping course
2. Language of thematic mapping course you teach
3. Method and learning objectives of the thematic mapping course you teach
4. Organization of the thematic mapping course you teach
5. The thoughts about another method of teaching thematic mapping (online teaching or teaching with tools)

A.2 EXPERT INTERVIEW TECHNICAL GUIDE

The interviewee Information

1. Name
2. Institution
3. Appointment

Technical guide for interview

1. What? This interview is about the method that you, as the teacher, use for teaching thematic mapping or thematic cartography
2. When? The interview will be held on the educator's preferred date and time as the source. The duration of this interview is 35-45 minutes
3. Where? This interview will be an online interview at a zoom link which will be shared the day before the interview is conducted as a reminder.
4. How? After the educator accepts the interview request, the appointment will be arranged. The researcher will lead the interview, asking the question which will be explained in the next section. The interview will be audio-recorded as the interview documentation, but only if it is allowed by the interviewees.

About Open Educational Resources What is Open Educational Resource or OER?

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The list of questions Pre-question: Is it OK to audio-record this interview for my documentation? Then, the audio will not be published everywhere, only as my documentation.

The factual question regarding the class:

1. How many students join the Thematic Mapping class?
2. What is your student background? How familiar are they with Thematic Cartography or Thematic Mapping?
3. What language is used in your class?

The current practice of teaching thematic mapping:

1. What kind of Thematic Mapping do you teach? Is it included "Thematic Mapping" as a hard skill? Do you have an exercise part where the students have a chance to decide what thematic mapping technique they will apply to visualise their data?

2. What is the most important thing you emphasise in your class? The concept behind thematic mapping or the technique of thematic mapping?
3. What is the main learning objective of the thematic mapping class you teach?
4. How is the organisation of the thematic mapping course delivered to your students in general? What is your method of teaching? Based on textbooks, online courses, or exercises?
5. What kind of teaching do you prefer? Passive learning or active learning? → passive learning requires learners to absorb, assimilate, consider, and translate information → active learning requires students to think, discuss, challenge, and analyse information

The other methods of teaching thematic mapping:

1. Have you ever used a tool for supporting your class? For example, an online tool for creating a map or software for automatically generating a map.
2. What are the most important elements that need to be included in the thematic mapping teaching tool?
3. What do you think about online teaching for thematic mapping? Do you think online thematic mapping teaching would be different from in-class teaching?
4. If there is an OER which can be a tool for supporting your teaching class, will you use it? Or do you have any experience in creating an OER?
5. What kind of OER that can support teaching thematic mapping do you expect?

A.3 THE EXPERT INTERVIEW RESULT

Table A.1: Expert Interview Result

Begin of Table						
Question	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6
Students total	+150 students	+15 students	+80 students	+200 students	+200 students	+30 students
Students' background	Bachelor's students of Geography faculty in the second year	Bachelor's students of Geodesy and Geoinformation	Bachelor's and master's students in the first semester from various study program	Bachelor's students in the first year from the program Geography, Geodesy, and Educational Geography	Bachelor's students of Geodesy (5th semester and Spatial Planner (2nd or 4th semester)	Master's students in their first year from Geoinformation and Spatial Engineering
Language	Indonesian	German	English	German	German	English
Thematic Mapping as a hard skill	Yes	Yes	Yes	Yes	Yes	Yes
The most essential thing in the class is	Theory and application techniques	The techniques require the understanding of the theory behind	The concepts behind with providing more good map examples	Theory and application techniques	Theory and application techniques	Theory and application techniques

Continuation of Table A.1						
Question	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6
The main learning objectives/outcome	Understand the whole process of creating a thematic map	Understand the whole process of how to do thematic mapping	Understand design maps, produce maps, and critique maps	Understand basic skills in geodata processing, the selection of graphic design tools and the cartographic processing of map content	Understand about the fundamental concepts of thematic cartography. They can analyse and visualise geodata. Furthermore, to allocate graphic variables to data scales and apply visualisation methods.	Understand visualising the data into a map and judging the design from a map.
The organisation of the course	Lecture class and practical class	Textbook is a must-read. There is always practice and discussion in every lecture class	Lecture classes, and practical classes	Textbook is a must-read. There is always practice and discussion in every lecture class	Textbooks, and some online resources are needed. Every lecture class has an exercise part	Textbooks, and free books (open educational resources).
Passive/Active	Active	Active	The mixture of active and passive	Active	Active	The mixture of active and passive
Tool for teaching	GIS software	GIS and graphic designing software	A web-based tool which provides many resources from various online sources	GIS software	Open source GIS software	It depends on the student's preference. But mostly GIS software

Continuation of Table A.1						
Question	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5	Interviewee 6
The most important element in the tool	The communication between teacher and students	Basic knowledge about thematic mapping	The examples of good maps	Depend on the lecture topic. The understandable tool for supporting the teaching would fit best.	The creative tool to show the students how to visualise the data	Conceptually tell the students how to make a proper map
Online teaching vs in-class teaching	In-class teaching is preferable	In-class teaching is preferable	Online teaching with strong student engagement	A hybrid class for now.	A hybrid class for now.	In-class teaching is preferable
If there is OER for teaching thematic mapping, will you use it?	Yes, they want to use it. No experience in creating OER.	It depends on the quality of the OER. No experience in creating OER.	Yes, definitely. They have experience in creating OER.	Yes, it would be great to use OER to support the teaching. No experience in creating one.	Yes, definitely. No experience in creating OER.	Yes, definitely. They have experience in creating OER.
OER expectation	OER with the general design and applicable for teaching, OER explains data acquisition, data pre-processing and data visualisation and OER can explain how to map ABC (Abiotic, Biotic and Culture)	OER can explain the data scale, the characteristics of visual variables, the thematic map types they can choose and the elements of the map layout.	OER has a very good learning path, OER provides many good map examples, and OER is open for everyone to contribute (this one will take OER to the next level)	OER provides more knowledge about thematic mapping for students.	OER with gamification for the students to keep interested in the materials, and OER can build the knowledge from the beginning as a narrative OER which also provides the keywords related to important things.	OER should have a learning path because it is important to make sure that the students can understand the material
End of Table						

Appendix B

Usability Testing Documentations

The questionnaires are set up in ArcGIS Survey123. Below we attached the pretest questionnaire and post-test questionnaire interface in PC desktop. Afterwards, we included the questionnaires result in several pie charts as the visualisation, so it is easier to interpret.

Pretest - Thempe

Introduction to my research:

- The title of my thesis research: Open Educational Resources for Teaching Thematic Mapping
- Student's/researcher's Name: Zulfa Nur'aini 'Afifah
- Program: MSc in Cartography (Erasmus Mundus Joint Master Degree Program)
- University: My program is coordinated by the Technical University of Munich. Partner universities of my program are Technische Universität Wien, Technische Universität Dresden and ITC - University of Twente. I am doing this research at ITC - University of Twente.
- Product of my research: Prototype of THEMPE (THEmatic Mapping Practice and Explanation). THEMPE is An Open Educational Resource for Learning More About Thematic Mapping.

Instructions:

1. **Please fill in the pretest** until the last page where you can find the link to get to THEMPE
2. **Go to THEMPE** to learn about thematic mapping. Do your best at finishing the learning process.
3. Afterwards, you need to **do the post-test** in order to give feedback on learning from THEMPE. The link to the post-test can be found on the last page of this pretest.

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[Powered by ArcGIS Survey123](#)

Pretest - Thempe

Introduce yourself

Tell me the initial of your name*

max 3 letters


Your email address

the luckiest participants who get the incentive will be contacted via email

Where are you from?*

Point in the country where you come from.

It does not need to be in the exact position of where you live



Esri, USGS | Esri, FAO, NOAA, USGS Powered by Esri

No geometry captured yet.

Your age*

☐ 15-20☐ 21-25☐ 26-30☐ >30

Your occupation*

☐ Bachelor's student☐ Master's student☐ Not a student

<

Pretest - Thempe

Open Educational Resource (OER)

Introduction to Open Educational Resource:

What is an Open Educational Resource (OER)?

The Higher Education Authority (2009) in Marcus- Quinn & Diggins (2013):

Open Educational Resources can be defined as teaching, learning, and research resources that are in the public domain or have been released under an intellectual property license that permits their free use or reuse by others.

I am familiar with independent learning***I am familiar with open educational resources*****I am familiar with learning in online platform***[Back](#)[Next](#)

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Pretest - Thempe

Quiz related to Thematic Mapping/Thematic Cartography

Please do answer the questions, and do not be afraid of getting the wrong choice. This is not an exam.

What is the purpose of a thematic map?*

- ☐ to tell the audience about a specific geographical area
- ☐ to show a beautiful representation of information
- ☐ to visualize only geographic phenomenon distribution
- ☐ to represent one or more geographic phenomena, the location, and the attribute
- ☐ to show detailed statistical data

Which one is not a quality of a good map?*

- ☐ has clear features and is not overcrowded
- ☐ has a high complexity of data source
- ☐ legend or key is easy to interpret
- ☐ uses a good symbolization to demonstrate a clear point
- ☐ has a clear idea of what the map is trying to demonstrate

What visual variable is suitable for representing Population Density data on a thematic map?*

What visual variables are the best for representing Population Density data on a thematic map?

- ☐ Colour value or Size
- ☐ Orientation or Texture
- ☐ Colour hue or Size
- ☐ Colour value or Position
- ☐ Size or Shape

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Pretest - Thempe

Quiz related to Map Types

Please do answer the questions, and do not be afraid of getting the wrong choice. This is not an exam.

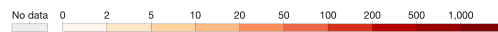
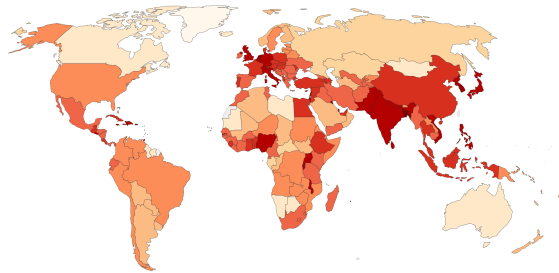
Choropleth Map

Here is an example of the Choropleth Map

Population density, 2022

The number of people per km² of land area.

Our World
in Data



Source: World Bank (2021), Gapminder (v6), HYDE (v3.2), UN (2019)

OurWorldInData.org/world-population-growth • CC BY

image source: <https://www.internetgeography.net/choropleth-maps-in-geography/>

Which data cannot be visualized with a Choropleth Map?*

- ☐ Covid case of Country X
- ☐ Life expectancy
- ☐ Population density
- ☐ Forest coverage of Region Y
- ☐ The direction of butterfly migration

Proportional Symbol Map

Here is an example of the Proportional Symbol Map:

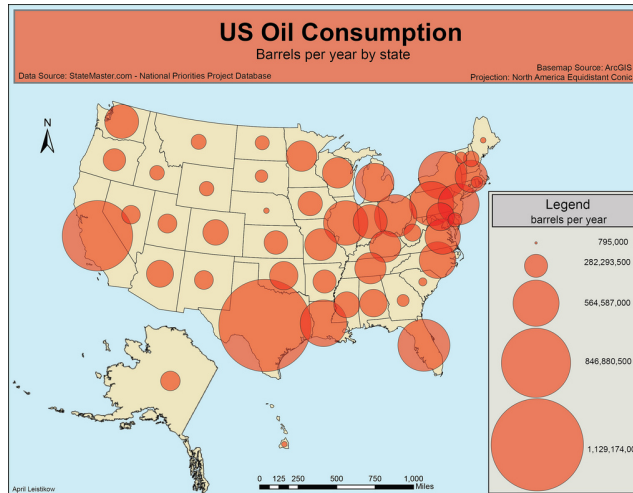


image source: <https://mappingignorance.org/2013/12/16/the-complexity-of-drawing-good-proportional-symbol-maps/>

Which data cannot be visualized with a Proportional Symbol Map?*

☐ Wheat Import Direction between Countries

☐ Oil Consumption of Region X

☐ Population of Country Y

☐ Number of Airports in Region Y

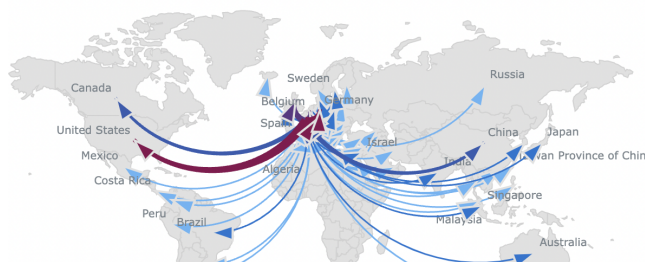
☐ Presidential Election of Country X

Flow Map

Here is an example of the Flow Map:

France's International Co-operation in Patents with Partners in 2018

■ Less than 0.5% ■ 0.5 - 1.5% ■ 1.5 - 3% ■ 3 - 5% ■ 5 - 10% ■ More than 10%






image source: <https://playground.anychart.com/fD11aJ1B/0>

Which visual variables can be used to visualize data with a Flow Map?*

☐ colour hue, shape, orientation

☐ colour hue, shape, colour value

☐ orientation, size, colour value

☐ colour hue, size, texture

☐ colour hue, size, colour value

Which data cannot be visualized with a Flow Map?*

☐ Wind currents

☐ Wheat imports in Europe

☐ Trans-Atlantic slave trade

☐ The direction of bird migration

☐ Covid case of Country X

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Pretest - Thempe

The Last Page of Pretest

Please follow the instructions on this page

The questions of pretest are easy*

☐ ☐ ☐ ☐ ☐

Strongly disagree Disagree Neutral Agree Strongly agree

I am confident with my answers*

☐ ☐ ☐ ☐ ☐

Strongly disagree Disagree Neutral Agree Strongly agree

Instructions:

1. Please **open the links** attached below to open THEMPE and the Post-test before submitting the Pretest! ⚠️
2. It will be great if **you can set the stopwatch** to see how much time you spent on learning.
3. Submit **this pretest** after opening both links below:

Link to **THEMPE** - Open Educational Resources: <https://zulfanaa.github.io/thempe>

Link to Post-test: <https://arcg.is/14Cury>

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Powered by ArcGIS Survey123

Post-test - Thempe

Introduction to this post-test:

- This post-test can only be done for everyone who finished learning with THEMPE
- There will be an incentive for 10 people (who will be drawn randomly from the participant ID list) €10 for each person. **Only the participants who finished the whole process including the pretest, learning from THEMPE, and post-test will get the chance.** The luckiest participants will be contacted via email on the 20th of August.

Instructions:

1. **Please fill in the post-test** just like the pretest
2. **Submit your post-test**

Next

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Powered by [ArcGIS Survey123](#)

Post-test - Thempe

Introduce yourself

Tell me the initial of your name*

max 3 letters

Your email address

the luckiest participants who get the incentive will be contacted via email

How long do you think you took to finish learning from THEMPE?*

☐ < 15 minutes

☐ 16-30 minutes

☐ 31-45minutes

☐ 46-60 minutes

☐ > 60 minutes

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Powered by [ArcGIS Survey123](#)

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Post-test - Thempe

Quiz related to Thematic Mapping/Thematic Cartography

Please do answer the questions, and do not be afraid of getting the wrong choice. This is not an exam.

What is the purpose of a thematic map?*

- ☐ to represent one or more geographic phenomena, the location, and the attribute
- ☐ to show a beautiful representation of information
- ☐ to show detailed statistical data
- ☐ to tell the audience about a specific geographical area
- ☐ to visualize only geographic phenomenon distribution

Which one is not a quality of a good map?*

- ☐ has clear features and is not overcrowded
- ☐ legend or key is easy to interpret
- ☐ uses a good symbolization to demonstrate a clear point
- ☐ has a high complexity of data source
- ☐ has a clear idea of what the map is trying to demonstrate

What visual variable are the best for representing Population Density data on a thematic map?*

- ☐ Orientation or Texture
- ☐ Size or Shape
- ☐ Colour hue or Size
- ☐ Colour value or Position
- ☐ Colour value or Size

[Back](#)[Next](#)

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Post-test - Thempe

Quiz related to Map Types

Please do answer the questions, and do not be afraid of getting the wrong choice. This is not an exam.

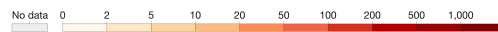
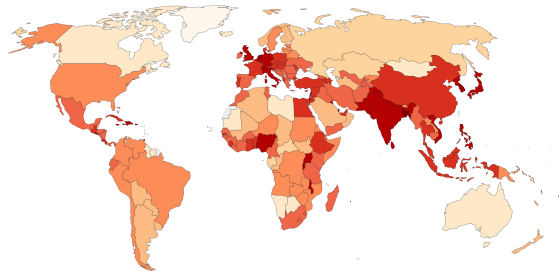
Choropleth Map

Here is an example of the Choropleth Map

Population density, 2022

The number of people per km² of land area.

Our World
in Data



Source: World Bank (2021), Gapminder (v6), HYDE (v3.2), UN (2019)

OurWorldInData.org/world-population-growth • CC BY

image source: <https://www.internetgeography.net/choropleth-maps-in-geography/>

Which data cannot be visualized with a Choropleth Map?*

☐ Life expectancy

☐ Forest coverage of Region Y

☐ The direction of butterfly migration

☐ Population density

☐ Covid case of Country X

Proportional Symbol Map

Here is an example of the Proportional Symbol Map:

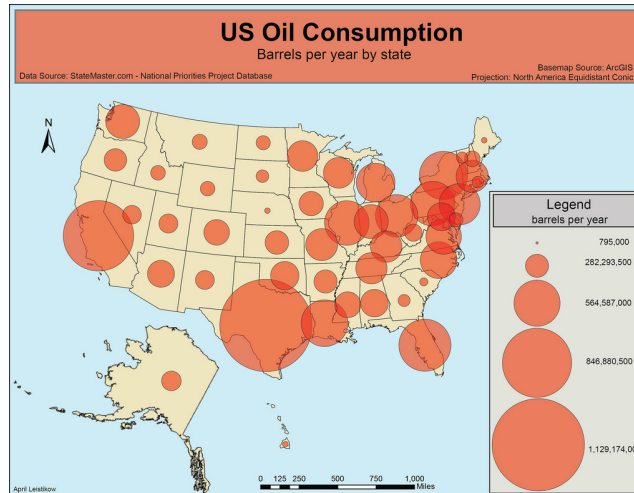


image source: <https://mappingignorance.org/2013/12/16/the-complexity-of-drawing-good-proportional-symbol-maps/>

Which data cannot be visualized with a Proportional Symbol Map?*

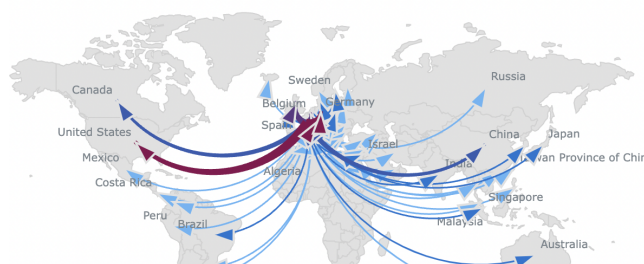
- ☐ Number of Airports in Region Y
- ☐ Population of Country Y
- ☐ Wheat Import Direction between Countries
- ☐ Oil Consumption of Region X
- ☐ Presidential Election of Country X

Flow Map

Here is an example of the Flow Map:

France's International Co-operation in Patents with Partners in 2018

☐ Less than 0.5%
 ☐ 0.5 - 1.5%
 ☐ 1.5 - 3%
 ☐ 3 - 5%
 ☐ 5 - 10%
 ☐ More than 10%






image source: <https://playground.anychart.com/fD11aJ1B/0>

Which visual variables can be used to visualize data with a Flow Map?*

- ☐ colour hue, size, texture
- ☐ colour hue, shape, colour value
- ☐ colour hue, size, colour value
- ☐ orientation, size, colour value
- ☐ colour hue, shape, orientation

Which data cannot be visualized with a Flow Map?*

- ☐ The direction of bird migration
- ☐ Trans-Atlantic slave trade
- ☐ Covid case of Country X
- ☐ Wheat imports in Europe
- ☐ Wind currents

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Post-test - Thempe

Questions Regarding to The Post-test

The questions of post-test are easy*

☐
☐
☐
☐
☐

Strongly disagree
Disagree
Neutral
Agree
Strongly agree

I am confident with my answers*

☐
☐
☐
☐
☐

Strongly disagree
Disagree
Neutral
Agree
Strongly agree

I am aware that the post-test questions are similar with pretest questions, there are many answers I changed after I learned from THEMPE*

☐
☐
☐
☐
☐

Strongly disagree
Disagree
Neutral
Agree
Strongly agree

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Post-test - Thempe

Feedback for THEMPE Contents

The materials*

Rate as much as you think the materials are easily perceived by you



The exercise and game of each page*

Rate as much as you like the exercise or practice section on each page. For example: The part where you can create your Choropleth Map



The way of explaining*

Rate as much as you like the way of explaining in THEMPE



I think learning with THEMPE is less effort than learning in the class*



I like learning with THEMPE because I can access it everywhere and anytime I want*



I like learning with THEMPE because it is freely-accessed by everyone*

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Post-test - Thempe

Feedback for THEMPE in General (The last page of Post-test)

Gamification*

Rate as much as you like the gamification in THEMPE

gamification: THEMPE has the lock-unlock with the quiz and the exercise or practice section on each page

**Design***

Rate as much as you like the design of THEMPE

**Quizzes***

Rate as much as you think that the quizzes are helpful for you to understand more about the materials

**I feel lock-unlock with the quiz is able to keep me excited learning from THEMPE*****I feel more engaged with THEMPE as a teaching tool*****What I like the most from THEMPE as an OER***

Change the order of these options below based on your preference

☐ The way of explaining

☐ The material

☐ The practice/exercise part (where you can play)

☐ The overall design

☐ The gamification (lock-unlock with quiz)

Reset

What I like the most from THEMPE

Please tell us the strong point of THEMPE and need to be preserved

1000

What I think can be improved from THEMPE

Please tell us the things that can be improved from THEMPE and need to be edited for the better THEMPE in the future

1000

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Submit

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B.1 THE STATISTICS OF PARTICIPANTS

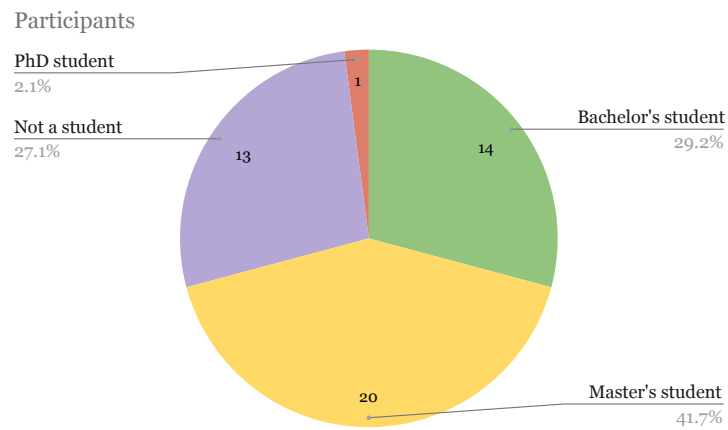


Figure B.1: Statistics of Participants

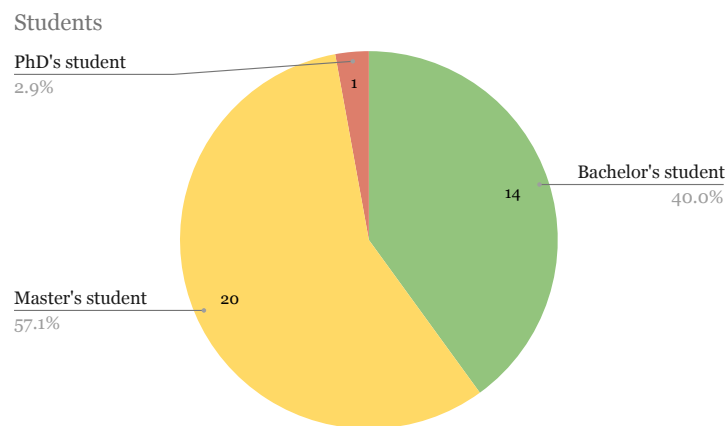


Figure B.2: Statistics of Student-only Participants

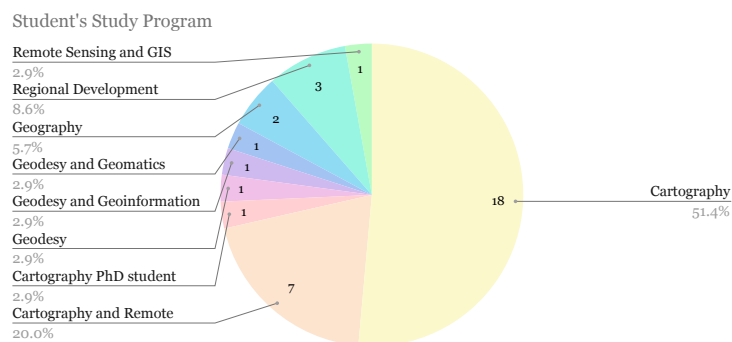


Figure B.3: Students' Study Program

B.2 PIE CHARTS FOR OER POTENTIAL ANALYSIS - USER TESTING RESULT

B.2.1 Pie Charts Related to Effectiveness Analysis

Completeness

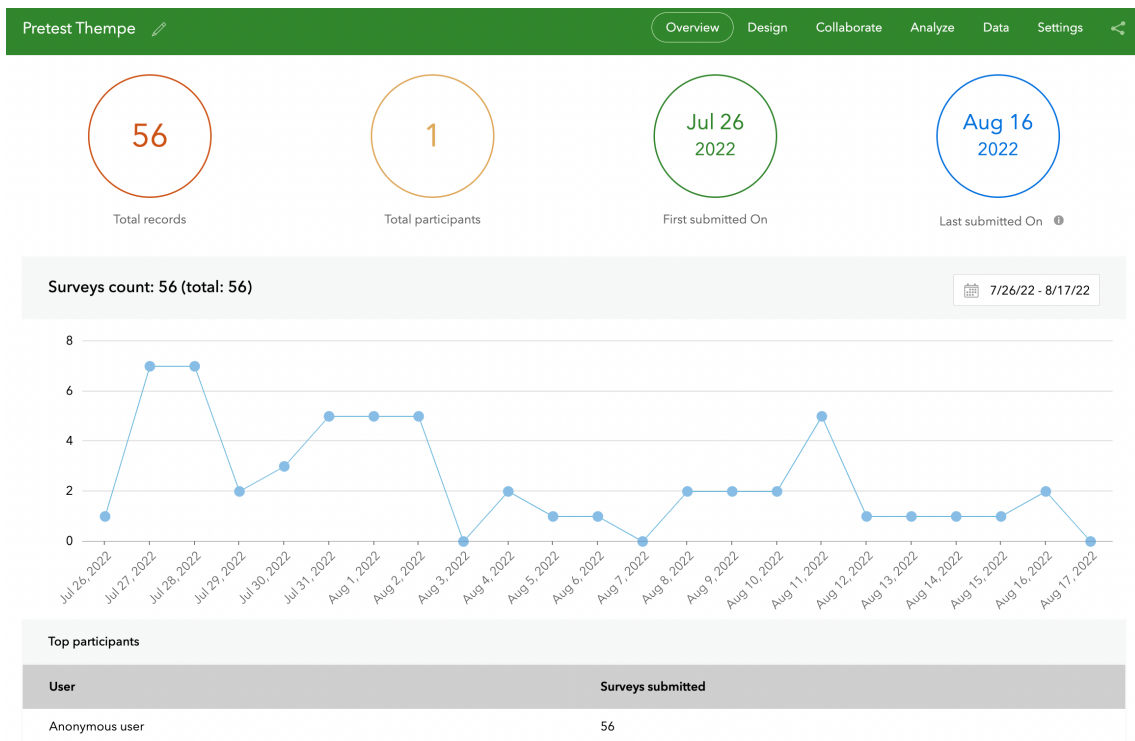


Figure B.4: Pretest Submission

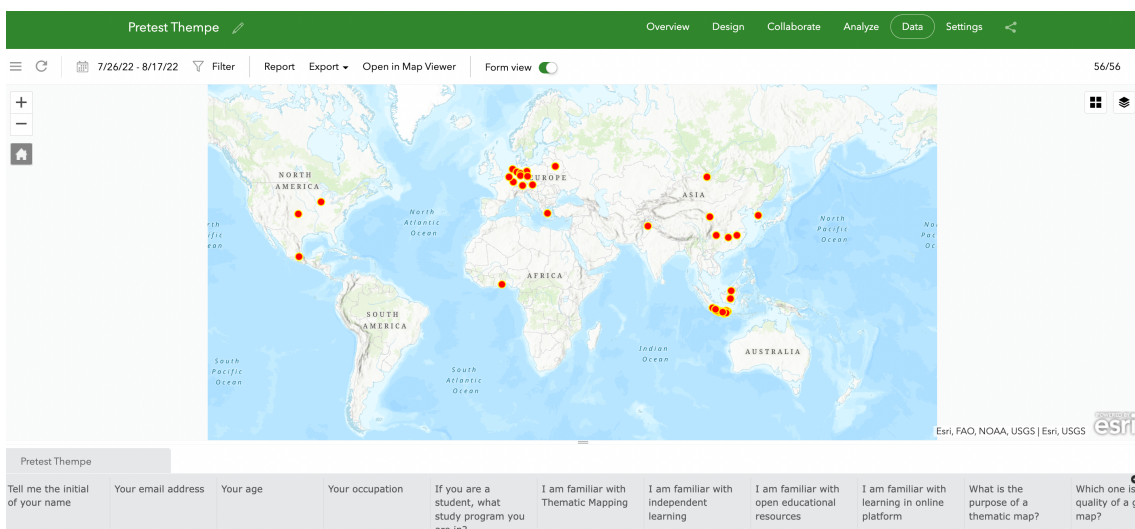


Figure B.5: Map of Pretest Participants Distribution

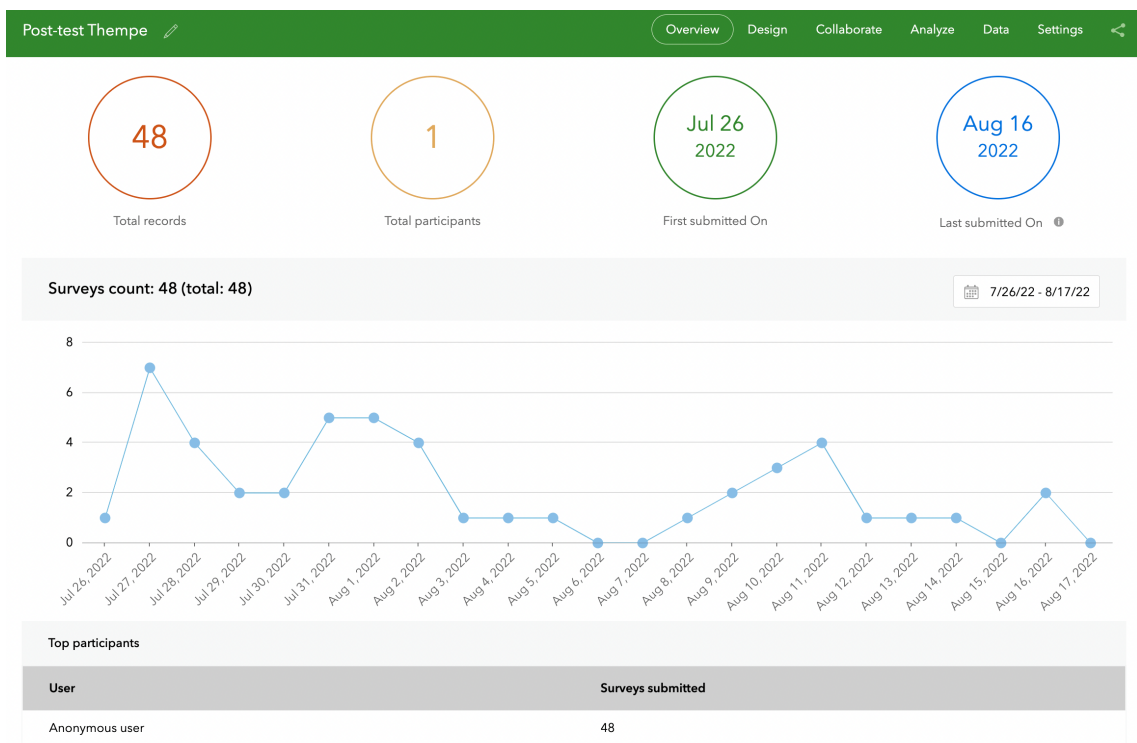


Figure B.6: Post-test Submission

Correctness in Answering Questions

- Overall correct answers

Count of Correct Answers

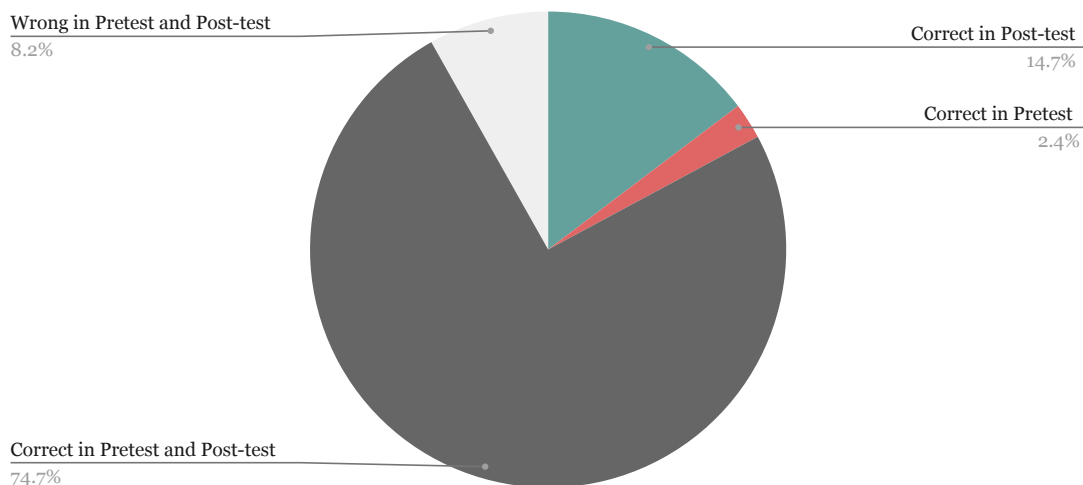


Figure B.7: Correct Answers from Student Participants

Count of Correct Answers

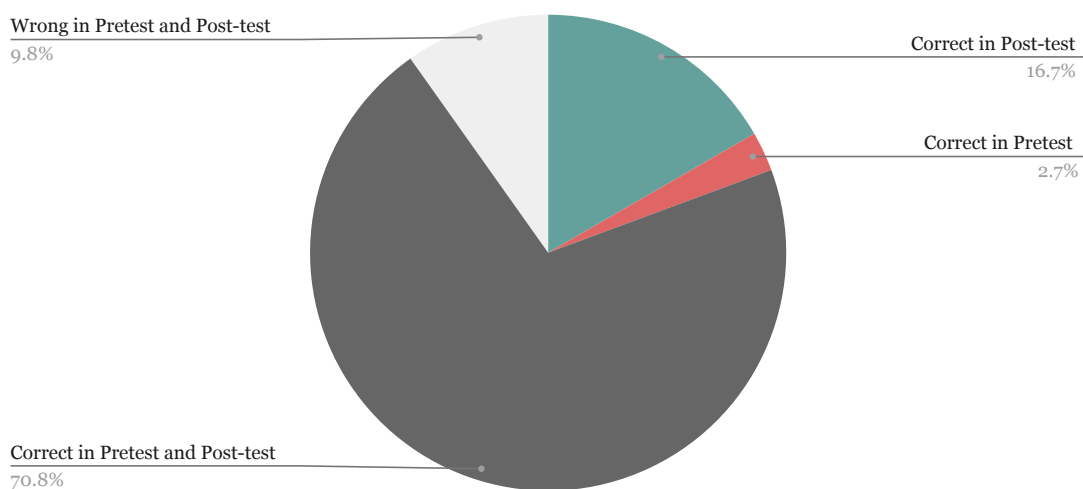


Figure B.8: Correct Answers from All Participants

- Question 1: What is the purpose of a thematic map?

What is the purpose of a thematic map?

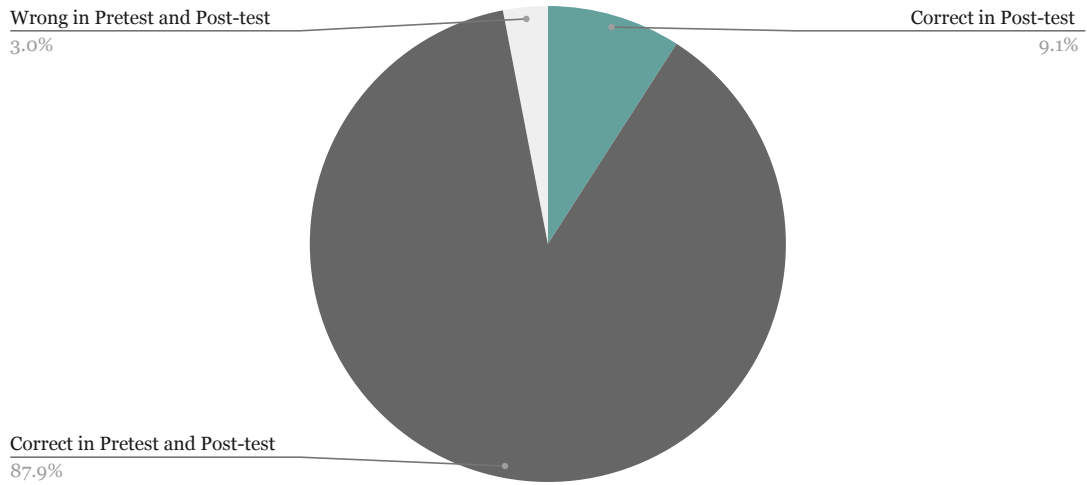


Figure B.9: Question 1 Answers from Student Participants

What is the purpose of a thematic map?

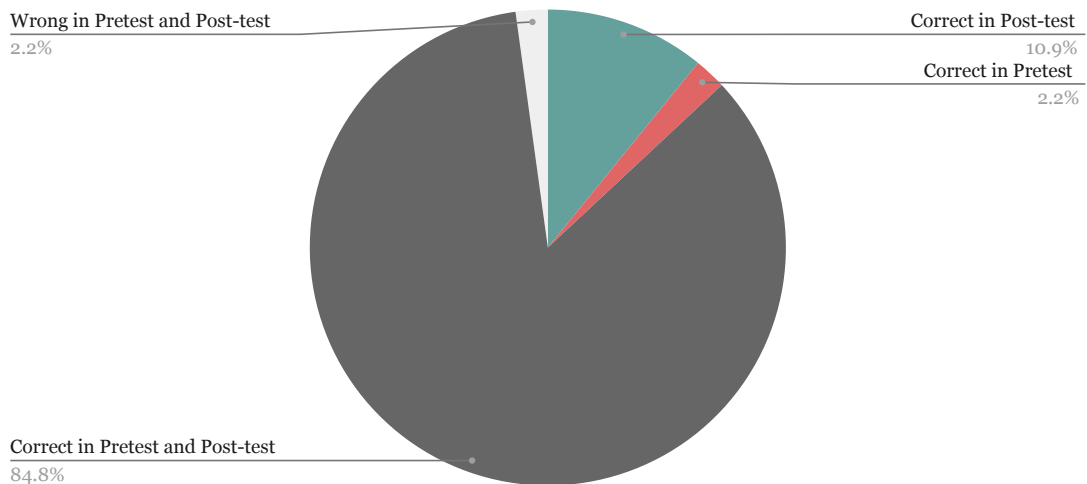


Figure B.10: Question 1 Answers from All Participants

- Question 2: Which one is not a quality of a good map?

Which one is not a quality of a good map?

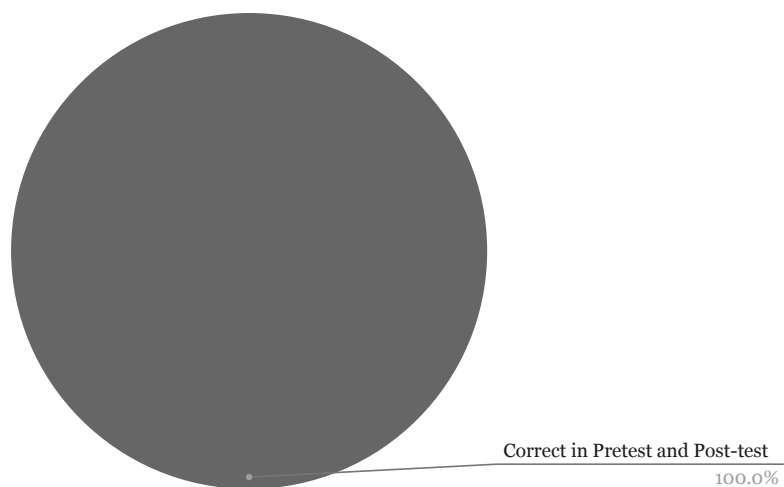


Figure B.11: Question 2 Answers from Student Participants

Which one is not a quality of a good map?

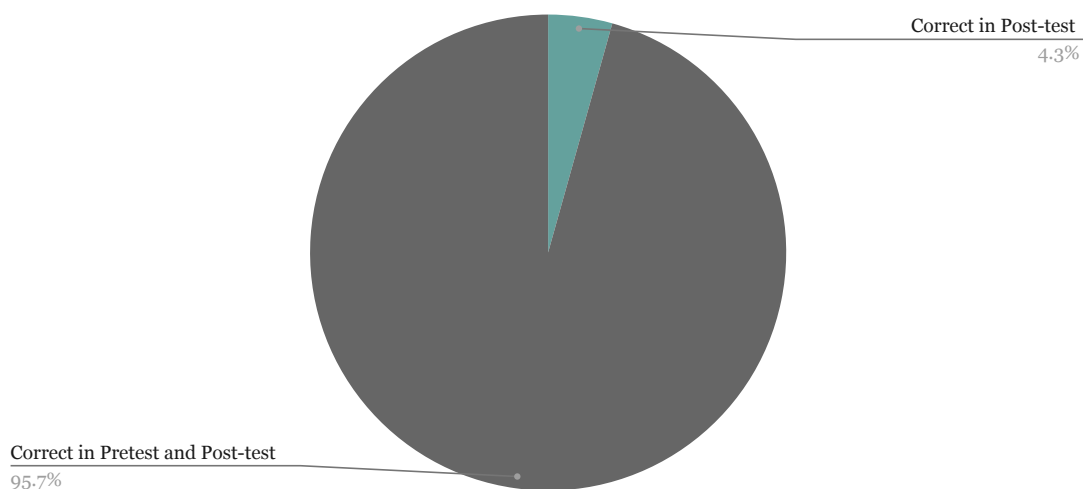


Figure B.12: Question 2 Answers from All Participants

- Question 3: What visual variable is suitable for representing Population Density data on a thematic map?

What visual variable are the best for representing Population Density data on a thematic map?

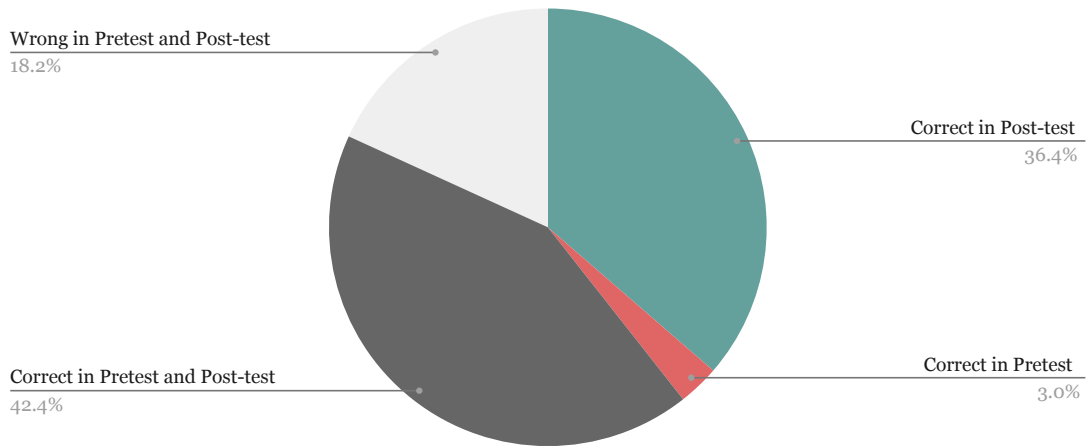


Figure B.13: Question 3 Answers from Student Participants

What visual variable are the best for representing Population Density data on a thematic map?

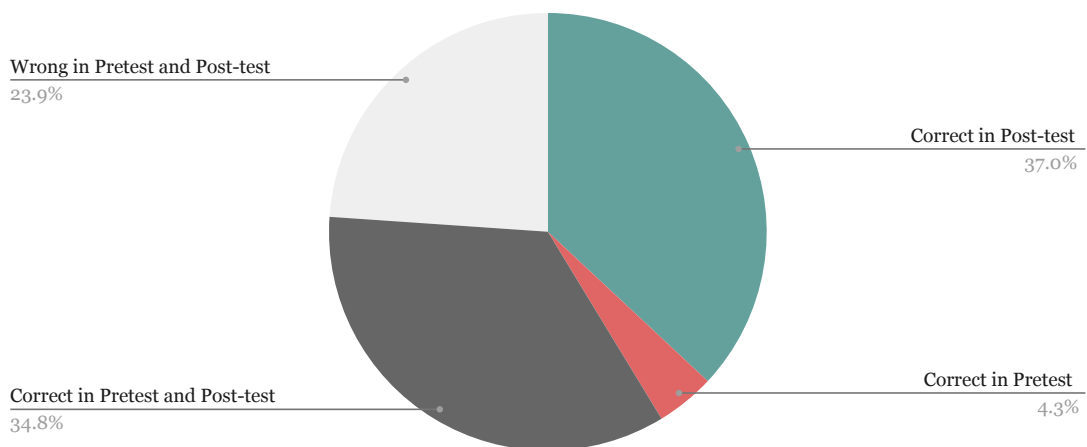


Figure B.14: Question 3 Answers from All Participants

- Question 4: Which data cannot be visualised with a Choropleth Map?

Which data cannot be visualized with a Choropleth Map?

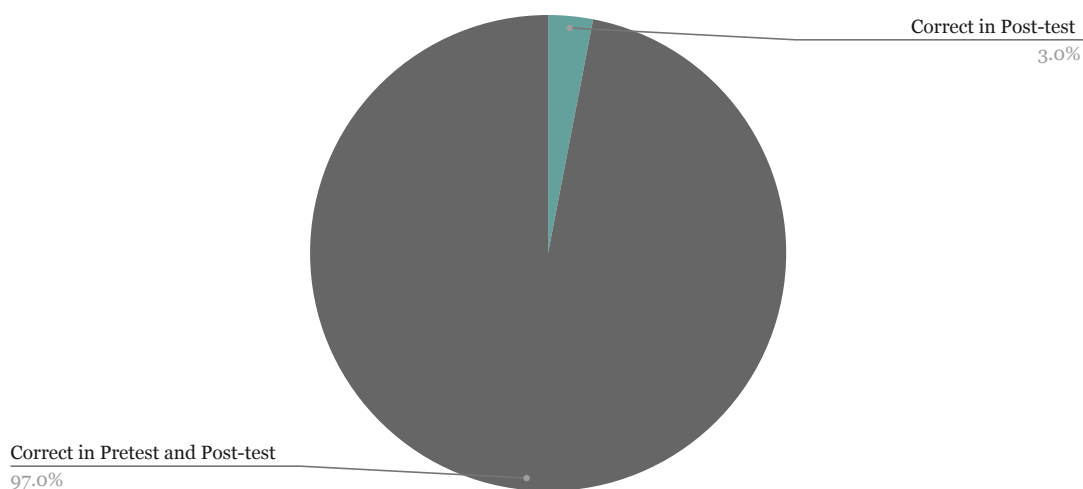


Figure B.15: Question 4 Answers from Student Participants

Which data cannot be visualized with a Choropleth Map?

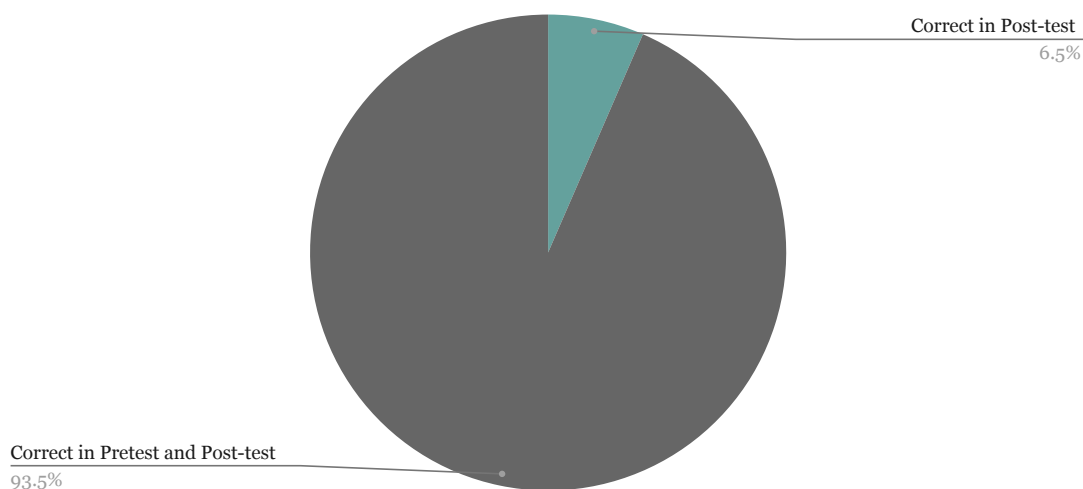


Figure B.16: Question 4 Answers from All Participants

- Question 5: Which data cannot be visualised with a Proportional Symbol Map?

Which data cannot be visualized with a Proportional Symbol Map?

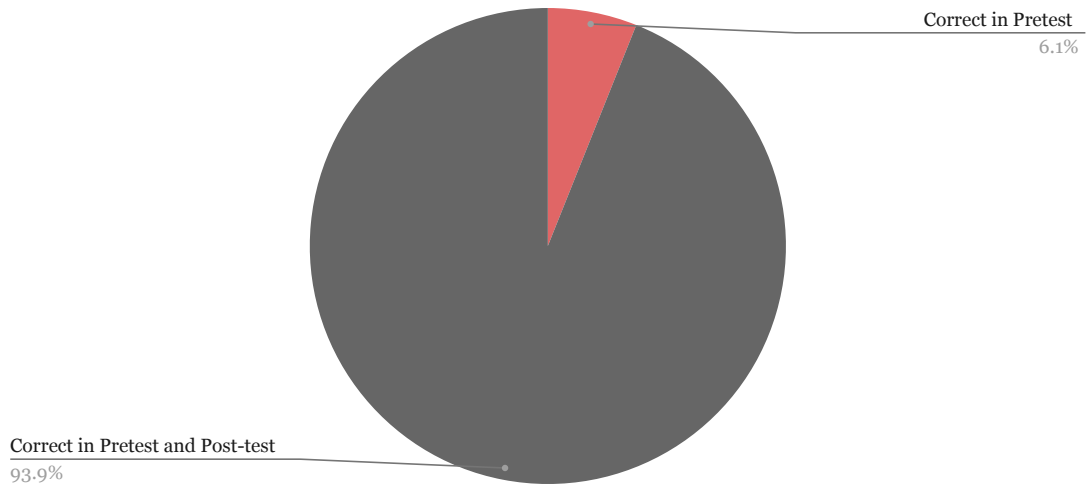


Figure B.17: Question 5 Answers from Student Participants

Which data cannot be visualized with a Proportional Symbol Map?

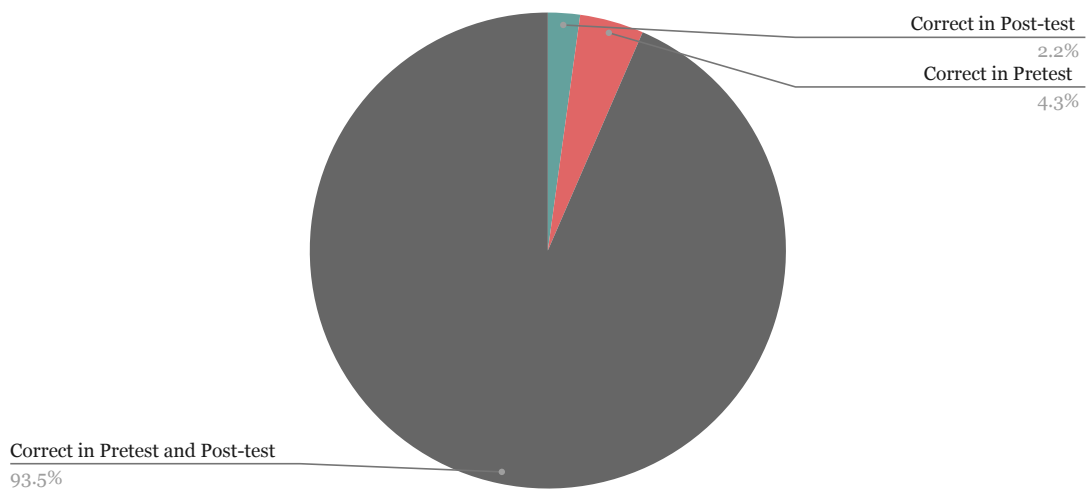


Figure B.18: Question 5 Answers from All Participants

- Question 6: Which visual variables can be used to visualise data with a Flow Map?

Which visual variables can be used to visualize data with a Flow Map?

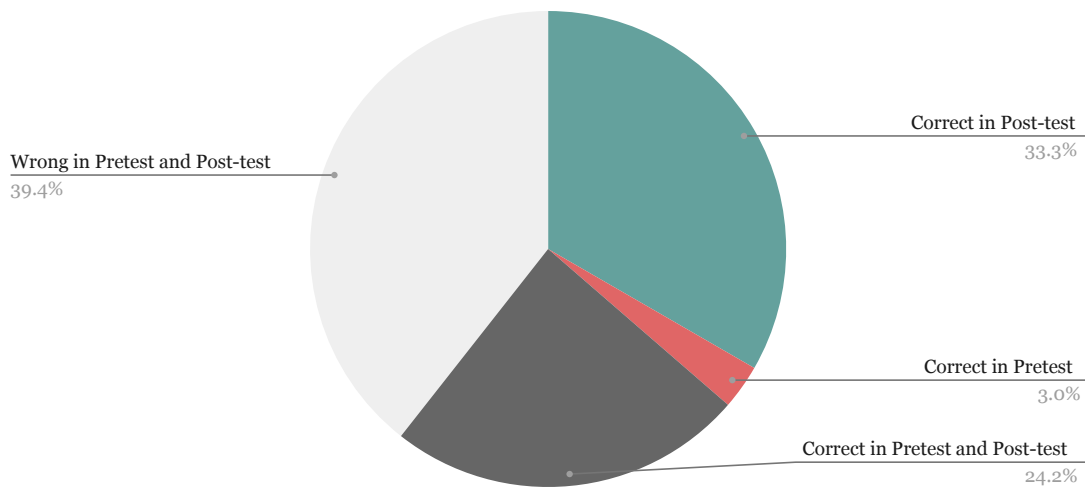


Figure B.19: Question 6 Answers from Student Participants

Which visual variables can be used to visualize data with a Flow Map?

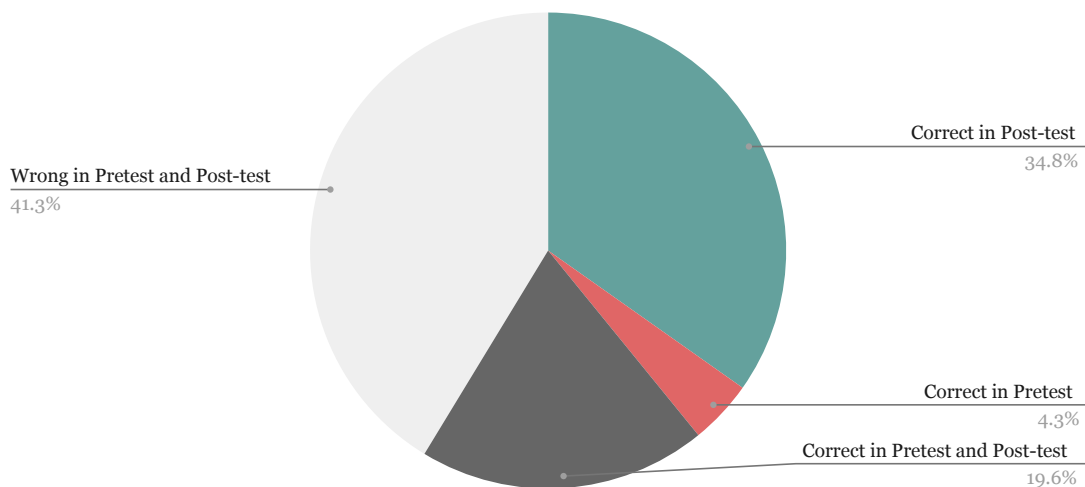


Figure B.20: Question 6 Answers from All Participants

- Question 7: Which data cannot be visualised with a Flow Map?

Which data cannot be visualized with a Flow Map?

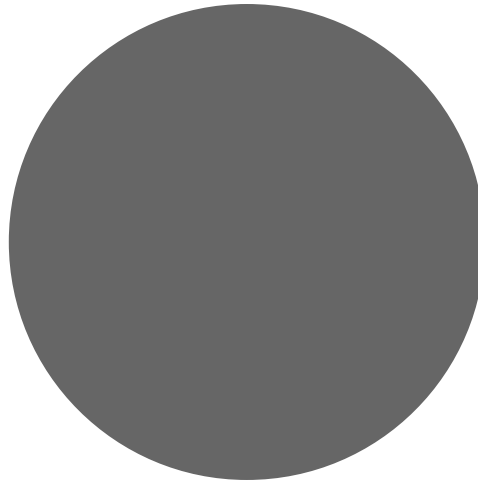


Figure B.21: Question 7 Answers from Student Participants

Which data cannot be visualized with a Flow Map?

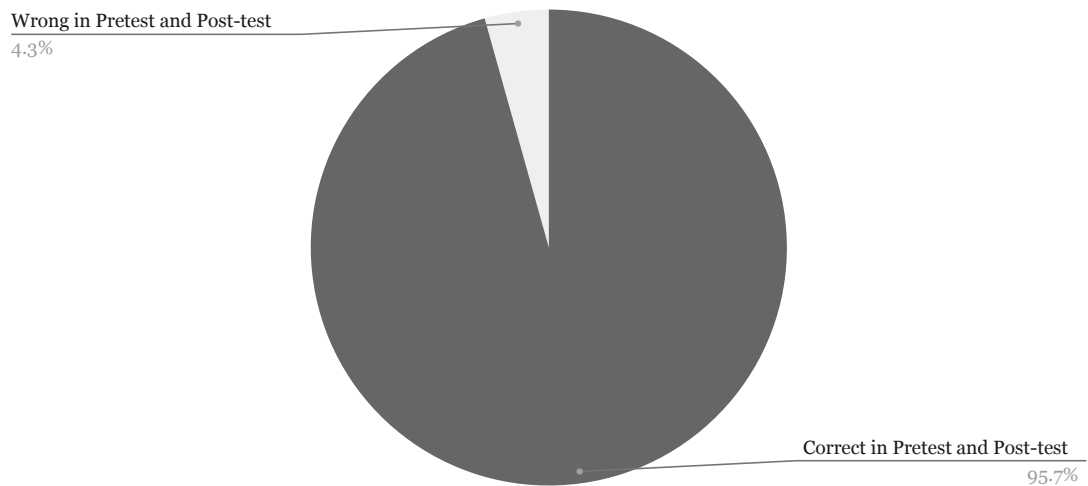


Figure B.22: Question 7 Answers from All Participants

- Are the pretest questions easy for the participants?

The questions of pretest are easy

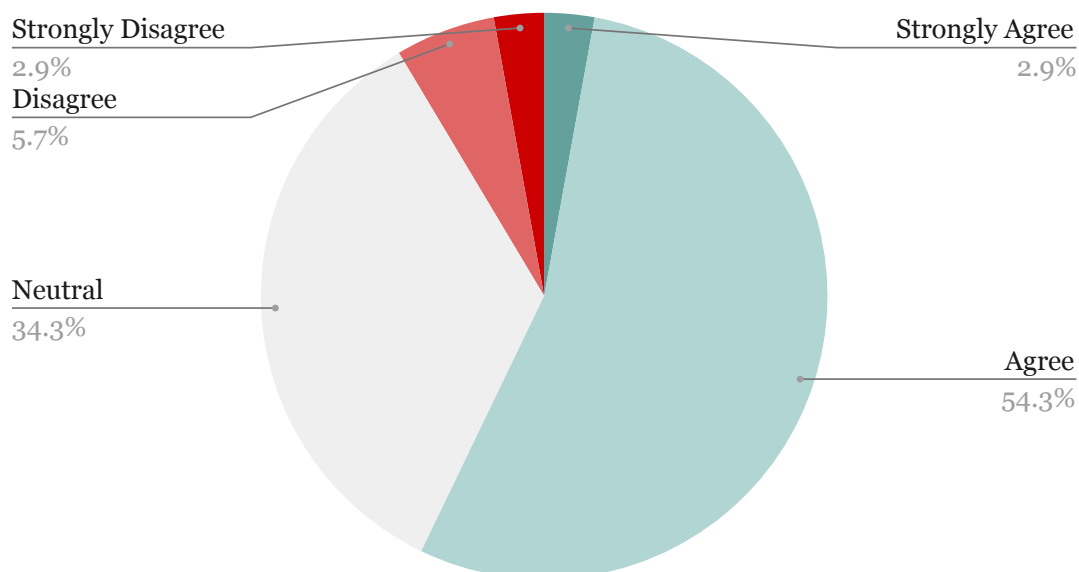


Figure B.23: How Students Participants Think About Pretest Questions

The questions of pretest are easy

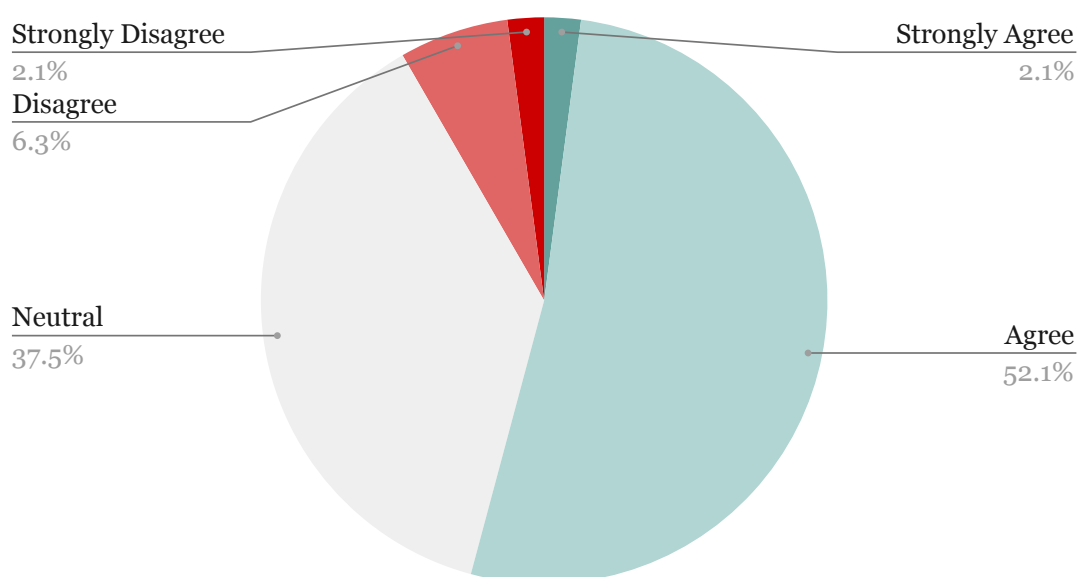


Figure B.24: How All Participants Think About Pretest Questions

- Are the post-test questions easy for the participants?

The questions of post-test are easy

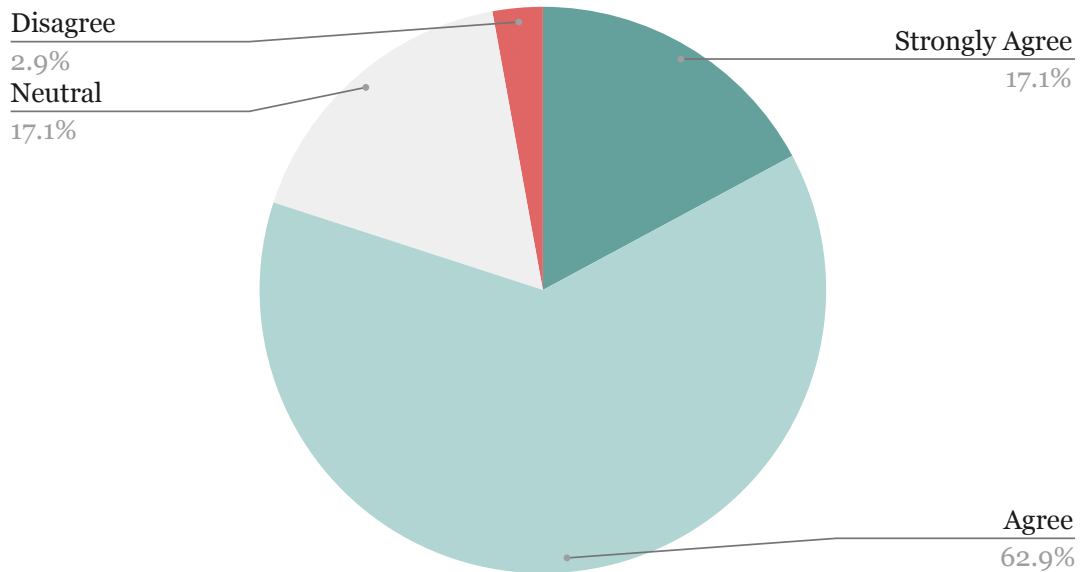


Figure B.25: How Student Participants Think About Post-test Questions

The questions of post-test are easy

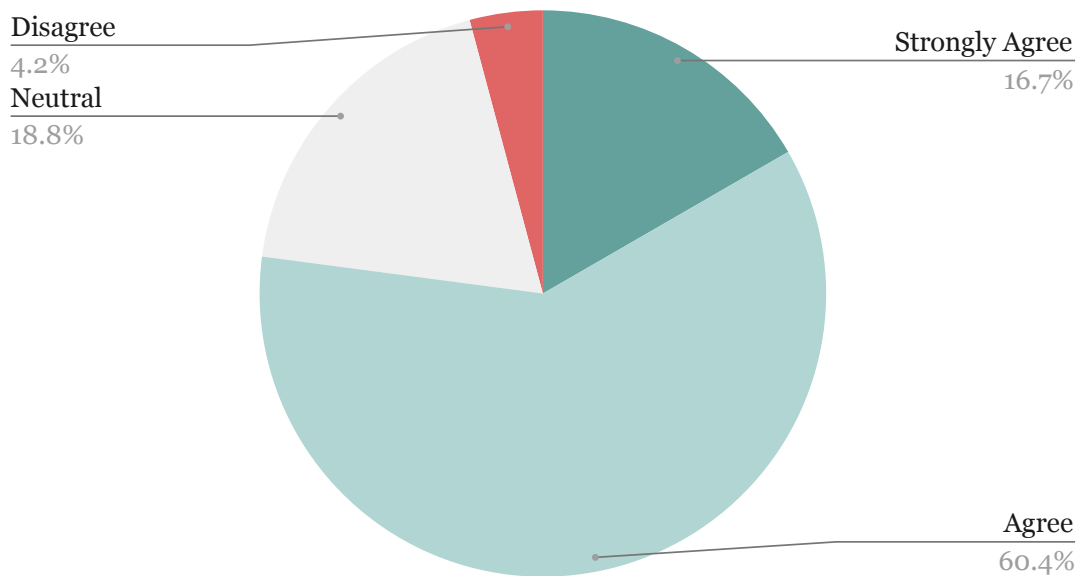


Figure B.26: How All Participants Think About Post-test Questions

- The Confidence of Participants for Answering Questions in Pretest

I am confident with my answers for pretest

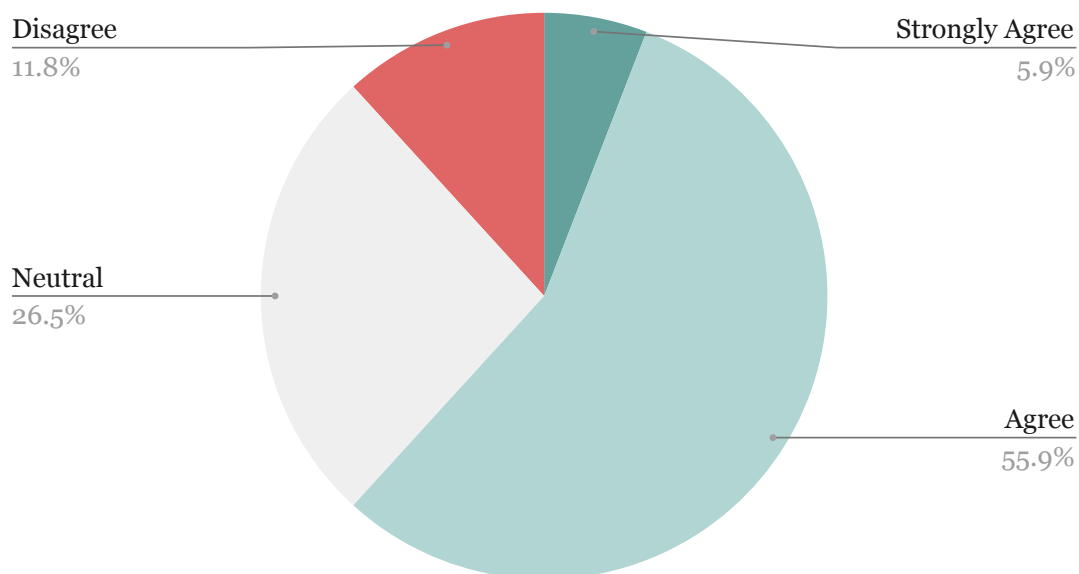


Figure B.27: How Confident Student Participants Answering Questions in Pretest

I am confident with my answers for pretest

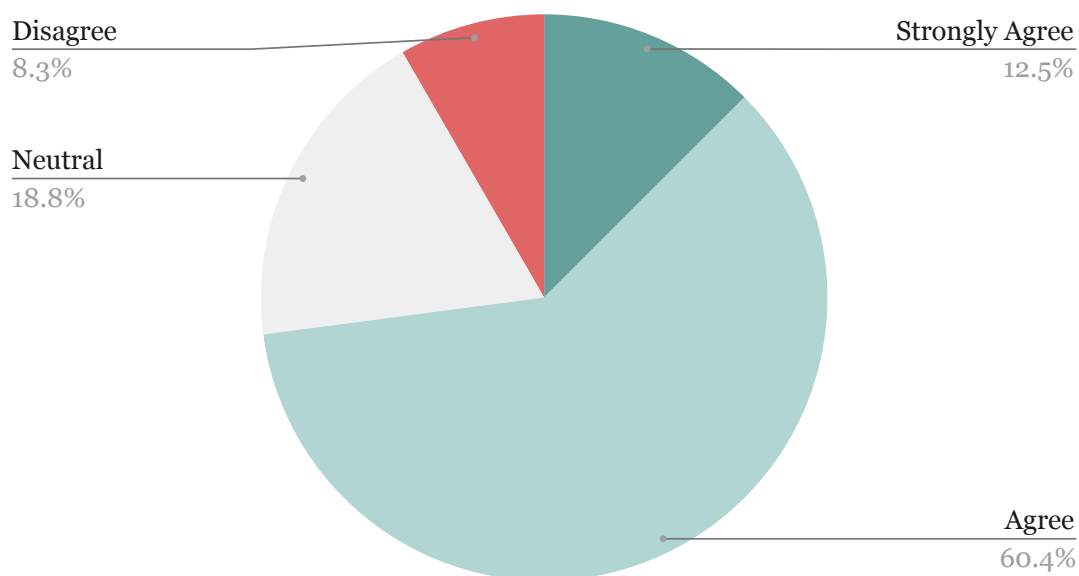


Figure B.28: How Confident All Participants Answering Questions in Pretest

- The Confidence of Participants for Answering Questions in Post-test

I am confident with my answers for post-test

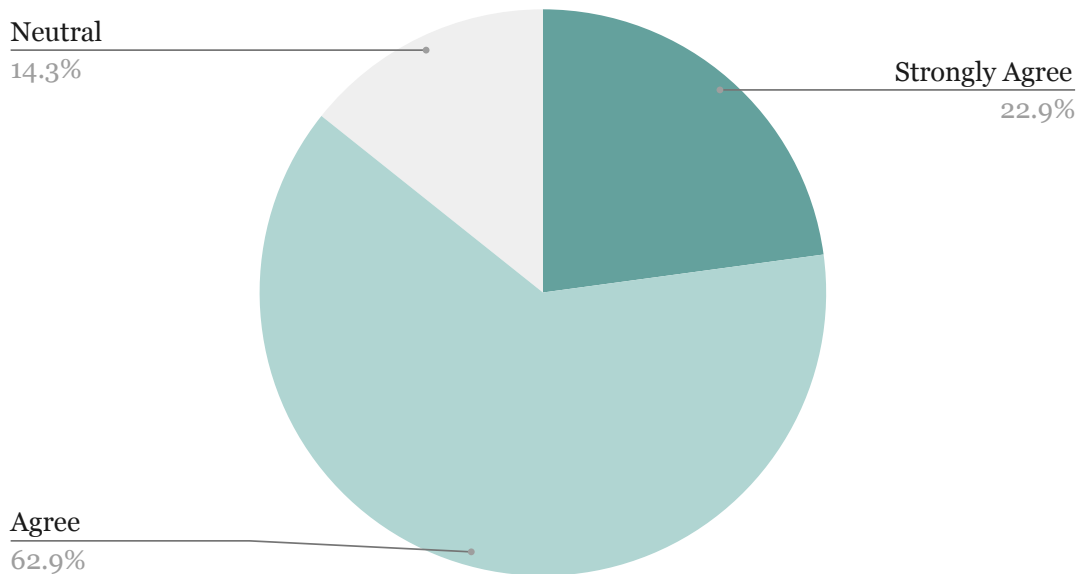


Figure B.29: How Confident Student Participants Answering Questions in Post-test

I am confident with my answers for post-test

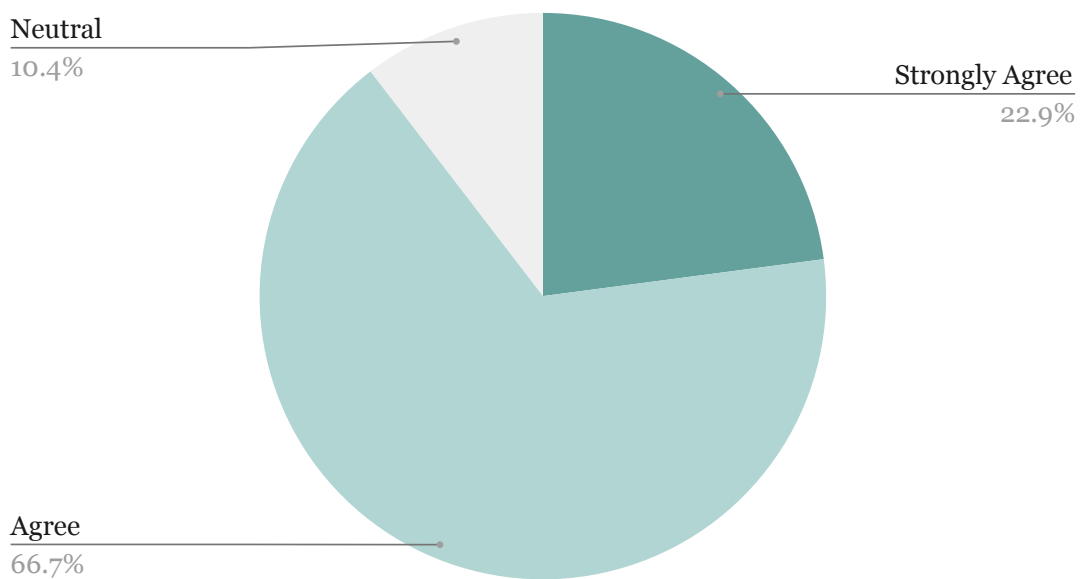


Figure B.30: How Confident All Participants Answering Questions in Post-test

B.2.2 Pie Charts Related to Efficiency Analysis

Duration of Finishing The OER Learning Process

How long do you think you took to finish learning from OER?

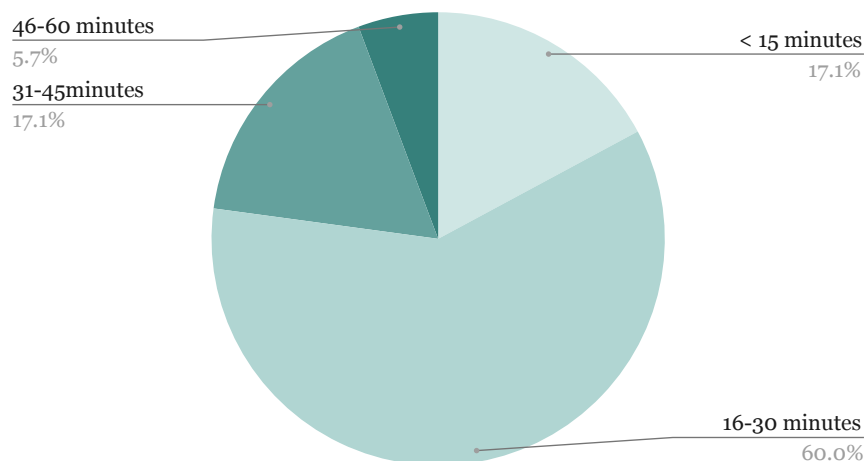


Figure B.31: How Long Students Finished Learning Process

How long do you think you took to finish learning from OER?

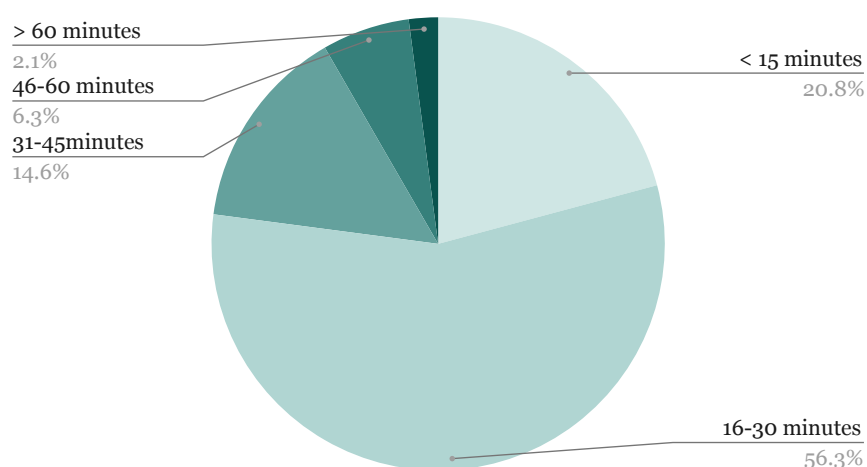


Figure B.32: How Long All Participants Finished Learning Process

Validation of OER Advantages

- The Statement: "I think learning with THEMPE is less effort than learning in the class"

I think learning with THEMPE is less effort than learning in the class

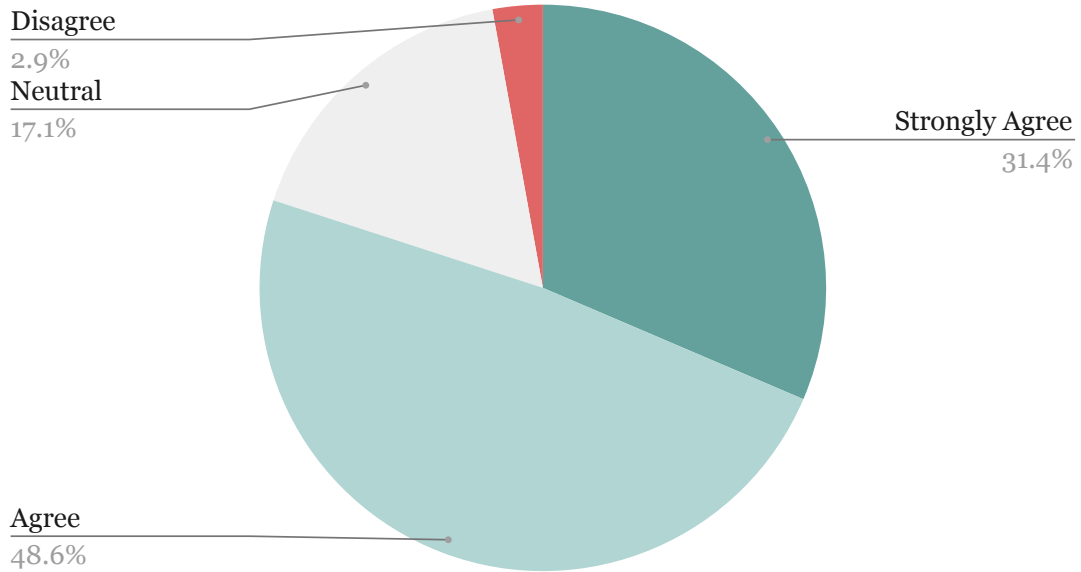


Figure B.33: What Students Think About The First Advantage

I think learning with THEMPE is less effort than learning in the class

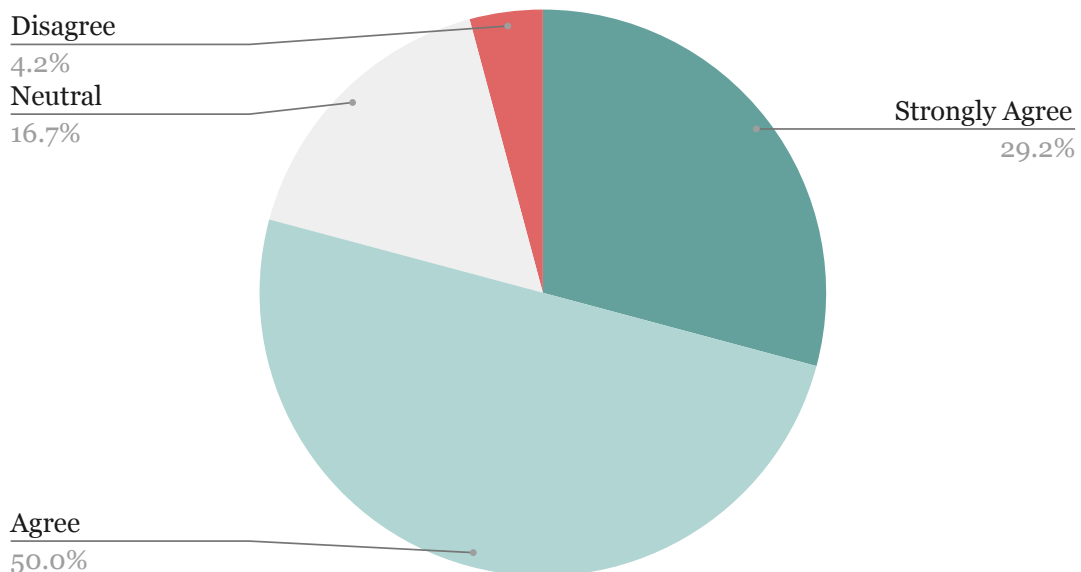


Figure B.34: What All Participants Think About The First Advantage

- The Statement: "I like learning with THEMPE because I can access it everywhere and anytime I want"

I like learning with THEMPE because I can access it everywhere and anytime I want

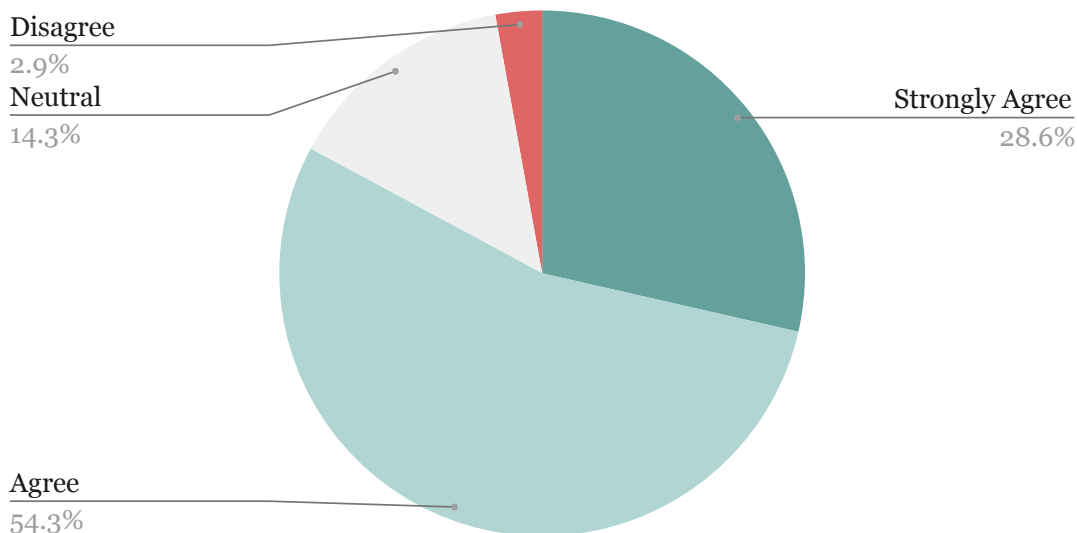


Figure B.35: What Students Think About The Second Advantage

I like learning with THEMPE because I can access it everywhere and anytime I want

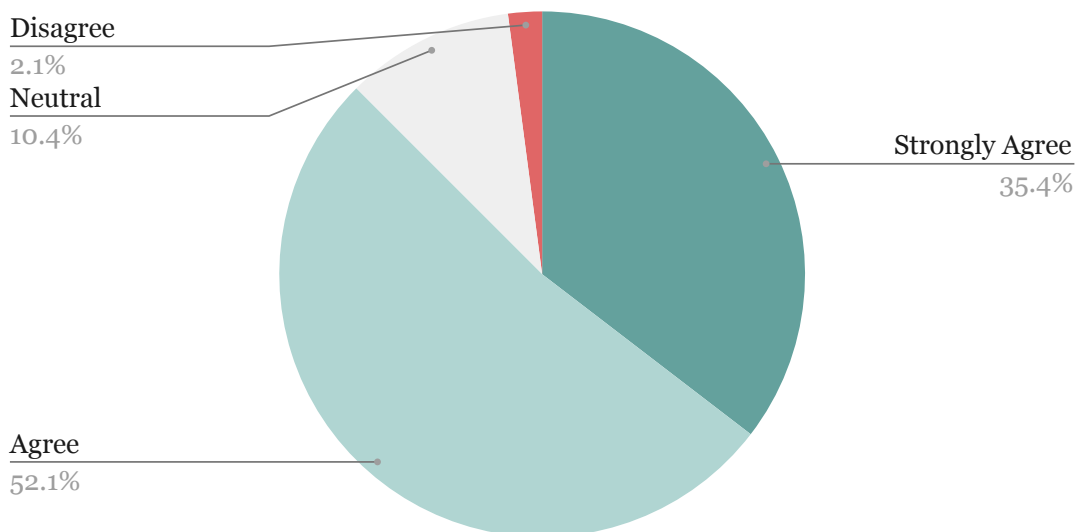


Figure B.36: What All Participants Think About The Second Advantage

- The Statement: "I like learning with THEMPE because it is freely-accessed by everyone"

I like learning with THEMPE because it is freely-accessed by everyone

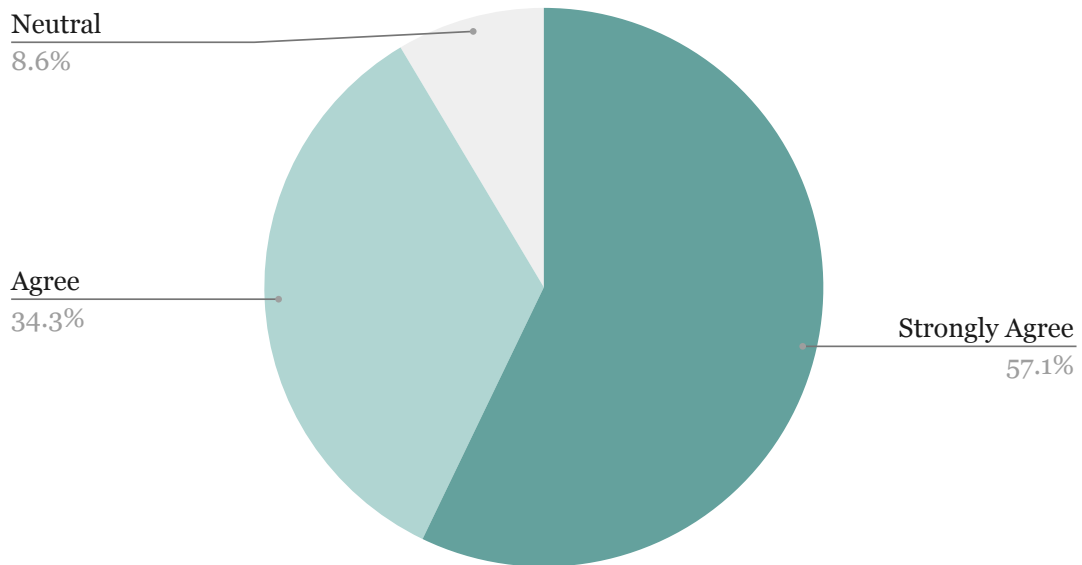


Figure B.37: What Students Think About The Third Advantage

I like learning with THEMPE because it is freely-accessed by everyone

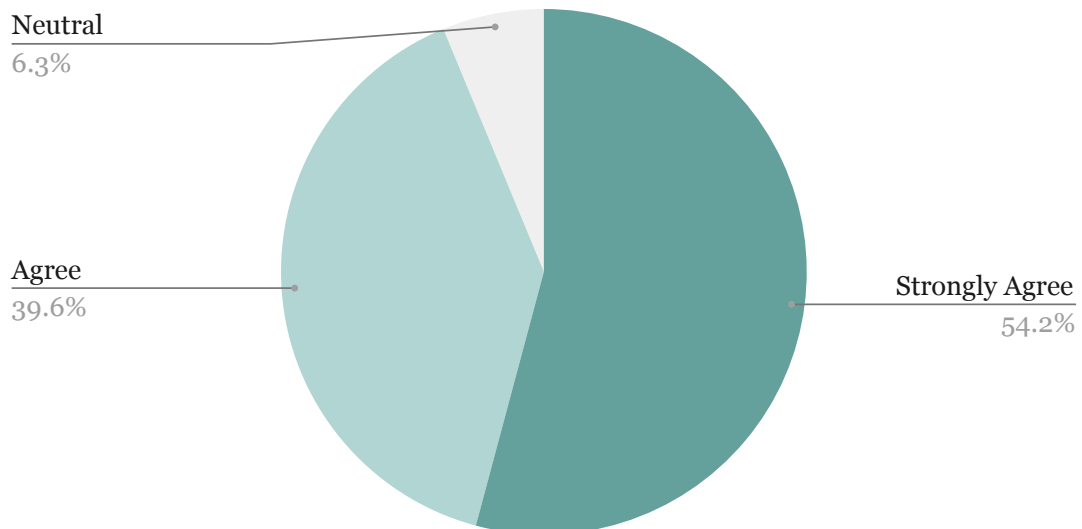


Figure B.38: What All Participants Think About The Third Advantage

Evaluation of OER Features

- The Statement: "I feel lock-unlock with the quiz is able to keep me excited learning from THEMPE"

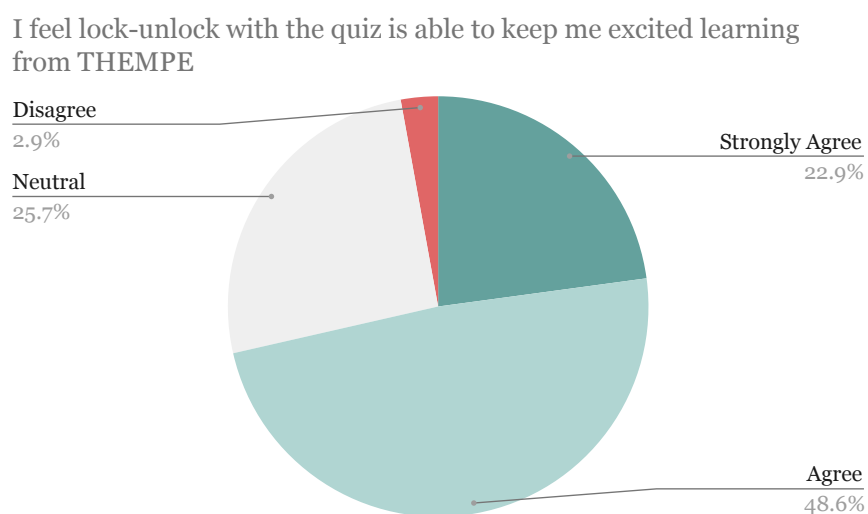


Figure B.39: What Students Think About The First Statement

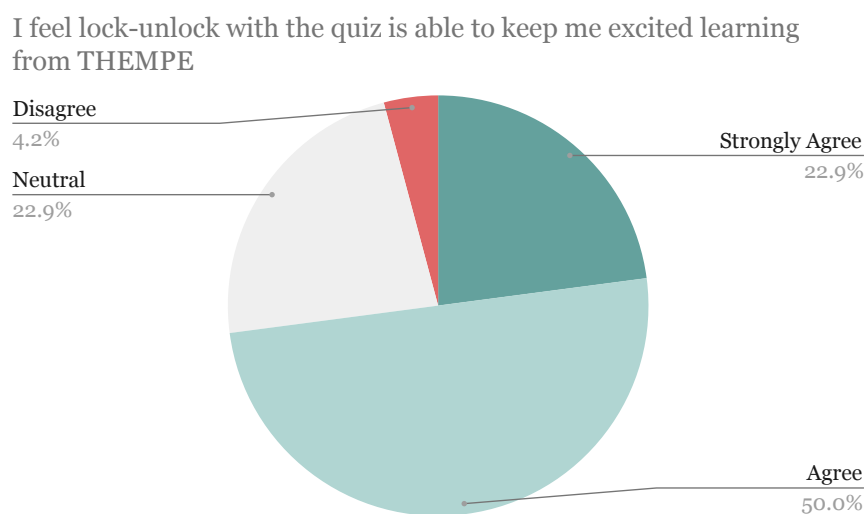


Figure B.40: What All Participants Think About The First Statement

- The Statement: "I feel more engaged with THEMPE as a teaching tool"

I feel more engaged with THEMPE as a teaching tool

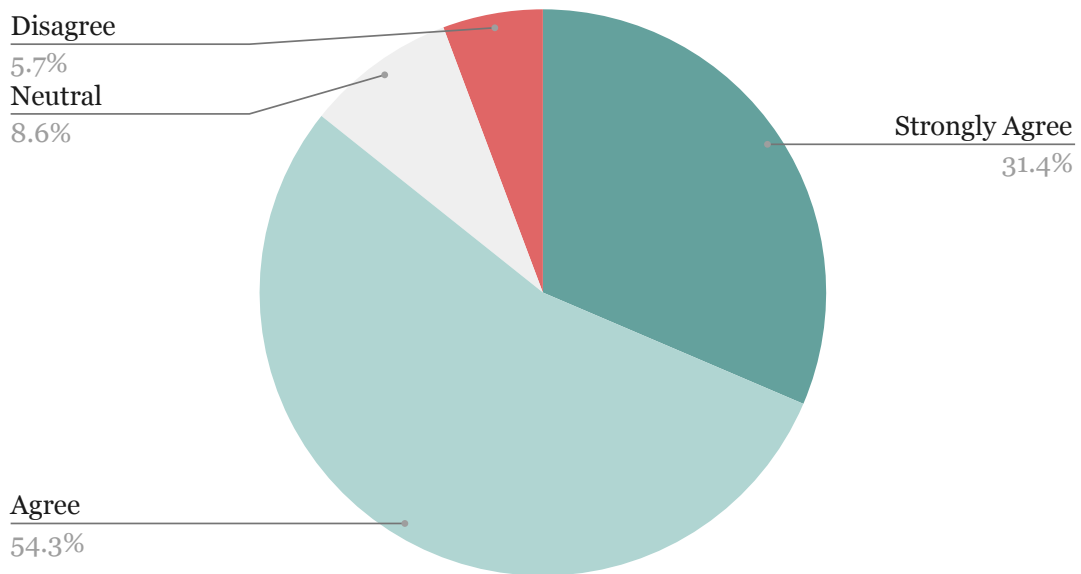


Figure B.41: What Students Think About The Second Statement

I feel more engaged with THEMPE as a teaching tool

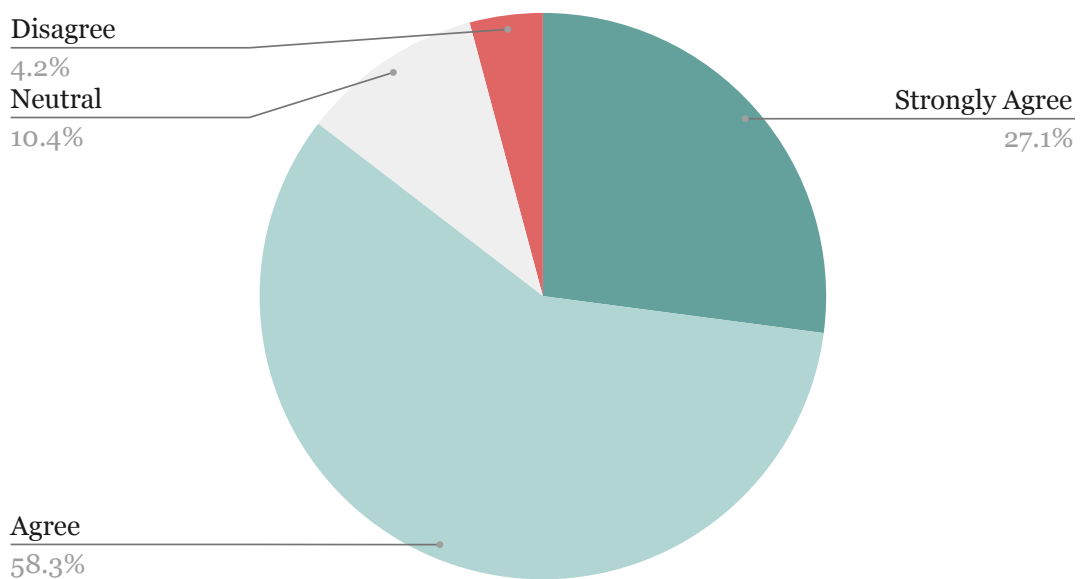


Figure B.42: What All Participants Think About The Second Statement

B.2.3 Charts Related to Satisfaction Analysis

- Rating Average for Each Aspect

Average Rating for Each Aspect

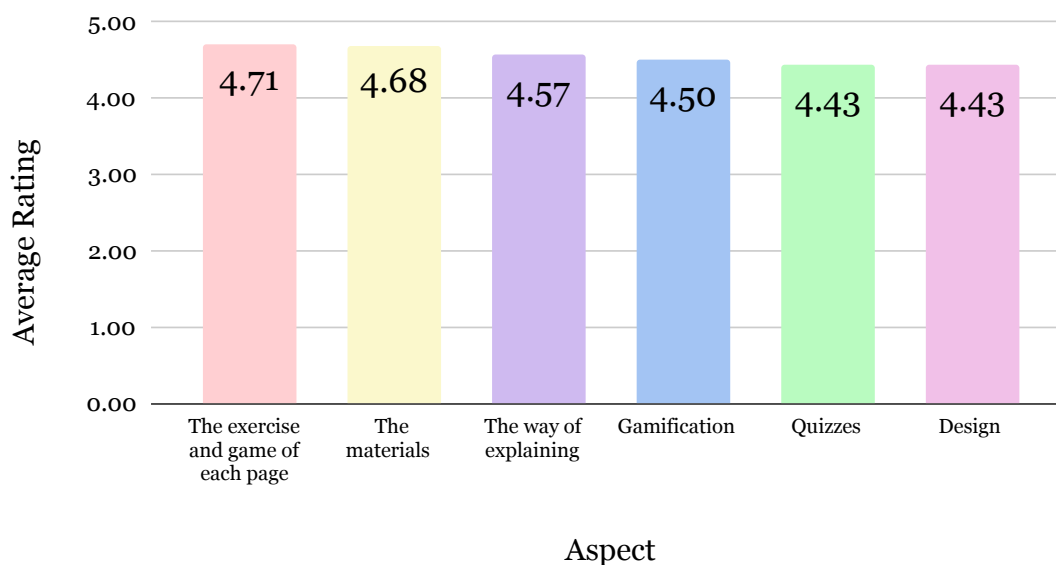


Figure B.43: Rating Average for Each Aspect Given by Students

Average Rating for Each Aspect

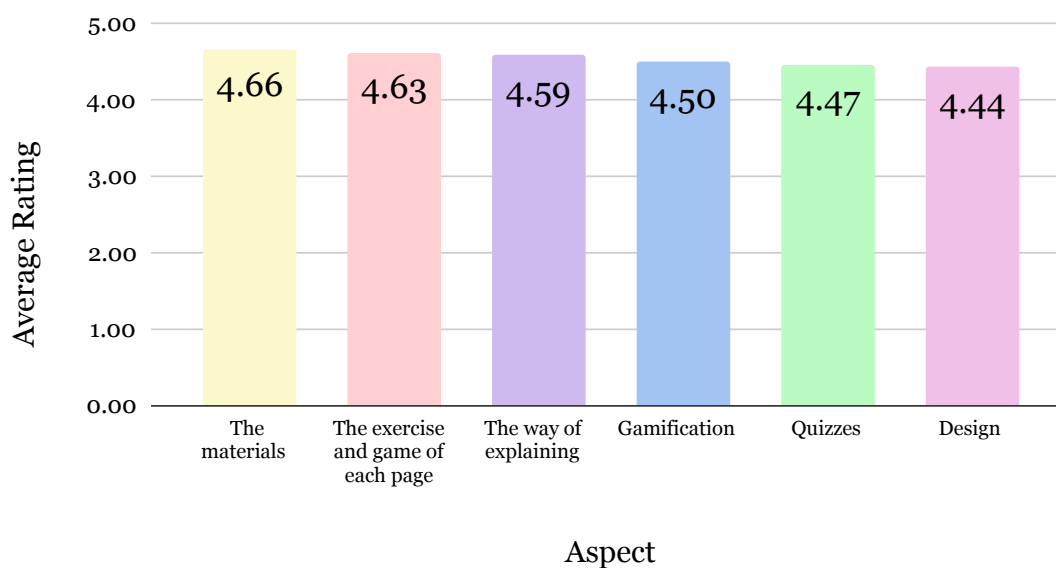


Figure B.44: Rating Average for Each Aspect Given by All Participants

- Ranking of OER Aspect: What The Students Like The Most from THEMPE



Figure B.45: What The Students Like The Most from THEMPE

There should be 35 students, but these similar initials made the count becomes 34 responses as shown in Figure B.46.

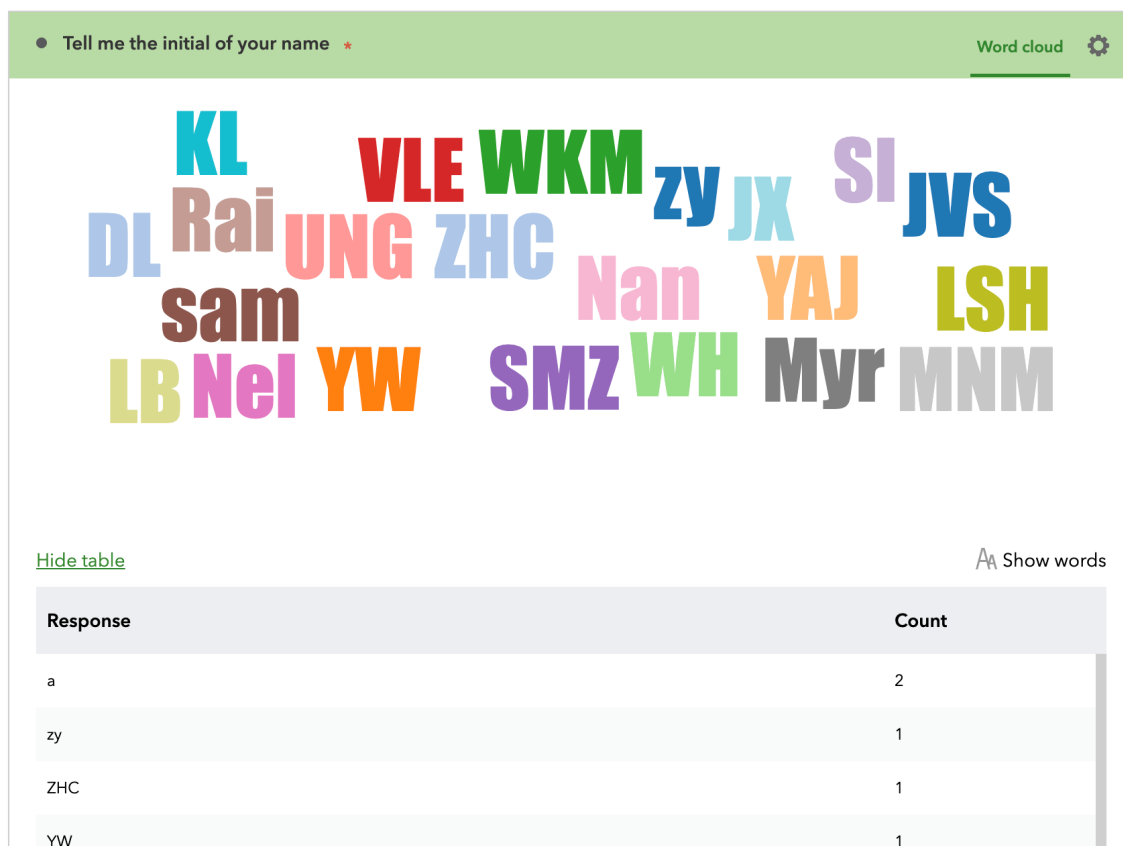


Figure B.46: Similar Initial Problem

- Ranking of OER Aspect: What All Users in User Testing Like The Most from THEMPE



Figure B.47: What The Users Like The Most from THEMPE

- Ranking of OER Aspect: What The General Users Who Are Unfamiliar With Thematic Mapping Like The Most from THEMPE



Figure B.48: What The Novice Users Like The Most from THEMPE