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PAPER

Enhancing Spatial Thinking Awareness of World-Scale Geography with Excel Dynamic Map Charts and Virtual Globes

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ABSTRACT

Spatial thinking is a unique thinking skill that geographers use to reason. Every individual is believed to have this thinking skill, but not all are aware of it. This condition causes differences in the development of each person. A person's spatial thinking can be improved by training. Geospatial technology is a representation tool that many people believe can be used to train spatial thinking skills. However, not many people encounter obstacles when using this technology. The complexity of the command to run is an obstacle that is often found. In line with the development of geospatial technology, many applications integrate this technology as part of visualization tools. This teaching and learning were conducted with Action Research Classroom (three cycles) in the form of Project-Based Learning with Science, Engineering, Technology, and Mathematic (STEM) approach. This article discusses the findings of the research on the use of Excel dynamic map chart and virtual globe to improve spatial thinking in research subjects with the case study of Indonesian Geography and World Regional Geography. With the Excel application project, for the context of upper-level education, the findings show an increase in spatial thinking skills and mastery of the use of mapping platforms without the need for prior experience of coding, software, or cartography, although it needs to be corroborated by other studies.

KEYWORDS

spatial thinking, Excel dynamic map chart, virtual globe, upper level education, Indonesian and world regional geography

1 INTRODUCTION

Spatial thinking skills are a very important component to achieve the goals of STEM and have been the focus of many studies over the past 100 years. Many studies have expanded on the types of spatial skills needed to be practiced in STEM [1]–[4]. STEM learning has given birth to great individuals so that until now STEM is very

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much implemented in teaching practices. This success is inseparable from spatial skills. Spatial skills enable learners to organize, reason, and understand spatial relationships in real or imaginary space [5], [6]. In fact, STEM professors often use spatial skills to complete their tasks. For example, a petroleum geologist uses his or her spatial skills by deciding the location for a new oil well to be drilled. These experts will interpret and visualize the shape and location of geologic structures into 3D that exist underground from 2D seismic data. These practices have thus encouraged STEM experts to make spatial skills a focal point of research and a target for intervention into education [6], [7].

Based on research on STEM teaching and learning, as stated in [8], spatial thinking skills have various thinking constructs. The report argues that spatial thinking skills should involve 3 components of spatial thinking that are characterized by spatiality related concept, tools of representation and cognitive process in STEM [4], [6], [8]. Spatial thinking skills are characterized by thinking with spatial concepts, using representational tools, and reasoning processes that are relevant to the given task [9], [10]. Spatial concepts based on the STEM approach refer to the meaning of space (dimension, perspective, and distance). The use of representation tools refers to diagrams, symbols, and the use of software to help represent spatial concepts and help solve problems and communicate results. The reasoning process generally involves the cognitive ability of learners to understand spatial concepts in different representations to describe and explain the phenomena/predict how spatial concepts may change over time [6], [8], [11].

Researchers view spatial thinking skills as an important and essential skill that can be learned and taught formally in the classroom [12], [13]. This is supported by the right tools, technology, and curriculum. With good support from educators and adequate technology, students' spatial thinking skills can become a lifelong habit of mind [14], [15]. Problems related to learning, teaching, and supporting spatial thinking skills are still seen today, such as the lack of adequate supporting tools to represent geographic data because it is so extensive. Another fact is also the lack of scientific understanding in education to widely accept spatial thinking skills and the low average score of 59, 36 on the research subjects. Therefore, the questions asked to learners should combine the three components (spatiality related concept, tools of representation, and cognitive process) so that it will help in building spatial thinking well. Combining three components in a question is better than using only one or two components.

The problem emerged during the process of writing this article by incorporating a type of technology to provide an opportunity to practice creating a visual representation tool for geography data. Learning and teaching are generally still text-based with no visuals to help represent geography data in the research subject's class. The author began to incorporate project-based learning and teaching strategies with a STEM approach, including the incorporation of Excel dynamic map charts and virtual globes technology in the learning materials. Any attempt to integrate the technology of Excel dynamic map charts and virtual globes must be implemented in a way that takes into account the fact of the low spatial thinking in the research subject's class. Therefore, the authors are not only interested in how to improve learners' spatial thinking but also in creating projects and questions that incorporate the three components of spatial thinking to build their reasoning and engagement with this technology.

Microsoft's Excel 365 product is a tool to help process geography data in improving spatial thinking with a STEM approach. Map Chart and 3D Map allow visualizing geography maps with the highest distribution details. This visualization is in the form of a display comparing values and categories. So that it can be interpreted in three components in spatial thinking skills.

2 METHODS

2.1 Research design

This research refers to the type of Action Research Classroom research. The Action Research Classroom model uses a spiral flow according to Kemmis and Taggart (1988). Kemmis and Taggart divided the research procedure into 4 stages in one spiral round, namely planning to action, action to observation, and observation to reflection. The action and observation stages are combined at one time so that the teacher can do it while in the classroom. Furthermore, the results of the observation are used to determine the next activity. This next activity is called replanning, which is an activity from the results of cycle I and which will be improved in cycle II and so on.

First, planning. The description of what will be done is to formulate a lesson plan, make learning tools and media, make a grid of spatial thinking questions in the form of essays, observation sheets, evaluation sheets, etc. The action (acting) and observation (observing) stages are carried out simultaneously. This action stage was carried out by making a project task for the PBL (project-based learning) learning model with a STEM approach. In the observation stage (observing), teachers observe project-making activities in the classroom. Furthermore, the last stage is reflection, which is applied by the teacher to assess the strengths and weaknesses of cycle I and decide whether to continue in cycle II.

Project Based Learning with STEM approach is the result of combining project assignments with the use of tools such as Excel dynamic map chart and virtual globe [16], [17]. PBL with STEM approach will be implemented by creating a dynamic map using map chart and 3D map tools on a case study of part of Indonesian Geography, as well as its application in World Regional Geography. Students will be divided into groups and work on project tasks with a mutually agreed time. In seeing the level of understanding, a pretest will be conducted at the beginning and after completing the project, a post-test will be given (questions after the project is completed). The score before making the project and the score after the project is completed are used to assess the level of spatial thinking of the research subjects, which is the main objective of this study.

Table 1. PBL and spatial thinking creation process

PBL X STEM Approach	Learning Experience	Spatial Thinking		
		Concept of Space	Using Tools of Representation	Process of Reasoning
Process 1 (Demand Analysis)	√	Spatial primitive, simple spatial, and complex spatial	Use (Excel)	Output
Process 2 (Analysis of Alternatives)	√			
Process 3 (Detailed Solution Analysis)	√			
Process 4 (Implementing and testing)	√			
Process 5 (Project packaging and sharing)	√			

Note: *Processes 1–5 are part of the learner worksheet.

Table 1 illustrates the learning experience that learners will do and get. The first to fifth processes are the steps that will be practiced in the worksheets of learners in 3 groups. The research subjects were 34 students consisting of 17 female students and 15 male students. In 1 group there are 10–11 students with a balanced distribution of men and women and with different capacities. Each group has one leader who will divide the tasks for each group member because not all group members will use one laptop.

This task is in the form of group members partly operating laptops, partly guiding procedures for making map charts and virtual globes, and partly collecting literature.

2.2 Justification

Data collection. According to Sugiyono (2015), data collection techniques are a major step in a study. The main purpose of this research is to get data. The data collected are non-test and test data. The collection consists of the following.

Research instruments

1. **Essay Test**

The test is a tool that measures students' understanding of spatial thinking concepts in the form of a number of essay questions. Essay questions are given in pretest and posttest activities. The following is a lattice of spatial thinking concept understanding test.

Table 2. Essay question grid

Basic Competencies	Basic Competencies	Indicator	Total Questions
3.3 Analyze food security, industrial materials, and the potential for new and renewable energy in Indonesia	4.3 Make a map of the distribution of food security, industrial materials, and potential new and renewable energy in Indonesia	3.3.1 Analyze/predict/compare the distribution of industrial materials through class discussions and map input/processing/output.	4
		3.3.2 Analyze/predict/compare the distribution of new and renewable energy through class discussions and map input/processing/output.	4
		3.3.3 Analyze/predict/compare the distribution of food security through class discussions and map input/processing/output.	4
Number of Questions			12

2. **Observation**

Observation is a data collection method conducted by teachers through direct observation of learning. The observation sheet can be a tool to help teachers in observing the use of Excel dynamic map chart to improve spatial thinking with STEM approach. In this study, there was one teacher as a researcher (teaching) and three teachers who helped as observers or were observers of the observation sheet. The observation guidelines are listed in the following table.

Table 3. Teacher observation sheet guidelines grid

Stage	Aspects Observed	Item Number	Observation Result
Introduction	Opened with greetings, prayers, and attendance.	1	....
	Provide apperception and motivation.	2	....
	Convey the purpose of learning.	3	....
Core Activities	Delivering material on natural resource management in the mining/forestry/marine sector.	4	....
	Learners process data to make graphical skill/2D/3D maps in groups.	5	....
	Learners analyze by making evaluations/speculations of the data used in mining, forestry, and marine sectors.	6	....
	Learners communicate the results by writing on the activity worksheet.	7	....
	Learners take a pretest/posttest to evaluate spatial thinking skills.	8	....
Closing	Summarize the learning and appreciate the project results.	9	....
	Close the lesson with a greeting.	10	....

2.3 Instrument testing

Validity test. Validity is an accuracy of research instruments in measurement. The validity test is divided into two, namely constructive validity and criterion validity (predictive criterion validity and concurrent criterion validity). In this study criterion validity, which focuses on comparing instruments that have been made with other instruments, was developed. This validity test uses testing tools such as IBM SPSS Statistic Version 25 using Pearson's Bivariate correlation (Pearson's Product Moment). This analysis is done by correlating each instrument score with the total score. This total score is the result of the summation of all instruments or question items. Question items that correlate significantly with the total score are said to have provided support in revealing what is intended. The following is the Pearson Bivariate correlation formula.

$$r_{xy} = \frac{n\Sigma x_i y_i - (\Sigma x_i)(\Sigma y_i)}{\sqrt{(n\Sigma x_i^2 - (\Sigma x_i)^2)(n\Sigma y_i^2 - (\Sigma y_i)^2)}}$$

Source: (Ramdhani et al., 2020).

Table 4. Table of validity test criteria

Validity Testing Criteria
The hypothesis is accepted if r count > r table = valid Hypothesis accepted if r count < r table = invalid

Source: (Ramdhani et al., 2020). *R table = df (N-2) is the significance level of the two-way test and can be seen through the R table.

Reliability test. Reliability is an index that describes the extent to which a measuring instrument can be trusted or relied upon. This reliability test is used to determine the consistency of the measuring instrument (remains consistent if measurements are repeated). There are several methods of testing reliability such as the retest method, Flanagan formula, Cronbach's alpha, KR-21, Hoyt's Anova, KR (Kuder-Richardson) formula-20 (Sugiyono, 2013). This reliability test uses testing tools such as IBM SPSS Statistic Version 25 using Cronbach's alpha. This method corresponds to a dichotomous score (0 and 1) and produces results equivalent to using the Hoyt Anova method, KR (Kuder-Richardson) formula-20. The following is the Cronbach's alpha formula.

$$r_{ii} = \frac{k}{k-1}\left(1 - \frac{\Sigma Si^2}{St^2}\right)$$

Source: (Sugiyono, 2013).

Table 5. Reliability test criteria table

Reliability Testing Criteria
The hypothesis is accepted if r count > r table = reliable. Hypothesis accepted if r count < r table = not reliable

Source: (Sugiyono, 2013). *R table = df (N-2) is the significance level of the two-way test and can be seen through the R table.

2.4 Data analysis

Classical completeness. Student learning outcomes are seen through individual or classical learning completeness. In this study, the researcher used classical completeness because it applied the Excel dynamic map chart to improve spatial thinking with project-based learning based on STEM approach. The following is the formula for classical completeness.

$$P = \frac{\Sigma\, siswa\ yang\ tuntas\ belajar}{\Sigma\, siswa} x\, 100\%$$

Source: (Gibertana Ginting, 2019).

Table 6. Table of classical completeness categories

Limitations	Category
P > 85%	Completed
P < 85%	Not Completed

Source: (Gibertana Ginting, 2019).

2.5 Procedure: overview and how to create Excel dynamic map charts and virtual globes

The Excel dynamic map chart technology can be used as a tool to support in comparing values and displaying geographic area categories. This technology is supported by the cloud and connected to Bing Map so that it can display maps in 2D and 3D. The visible map is the result of Bing Map service or online map developed by Microsoft in Excel 365 [18]. The data that can be used generally has geographic area data such as data containing countries/regions, states, counties, and postal codes. Excel will automatically recognize regions and create maps to visualize the processed data. Microsoft Bing company is a separate business with Microsoft 365 Apps managed by Microsoft. Users can have a new experience with Office applications included by Microsoft 365 Apps such as 3D maps (virtual globe), map charts, online image insert, online 3D model insert, Powerpoint Quickstarter, search for researchers, intelligent search engine, and plagiarism check [19]. Although it has the latest features, Excel 365 also still contains old features that are still used by users such as bar charts, pie charts, area charts, statistical and hierarchy charts, bubble, waterfall, funnel, stock, or radar charts, surface, and double charts.

The use of Excel dynamic map charts can be applied to the case study of Indonesian Geography and World Regional Geography in the material of food security, industrial materials, and new and renewable energy, through new Excel 365 features, namely graphical, map charts, and 3D maps (virtual globe). Graphical, map chart, and 3D map can visualize geography data with the highest or lowest distribution details. This visualization is in the form of a display comparing values and categories. Comparing values is shown in the form of two to three color variations. Areas with low values are shown with light color variations and areas with high values are shown with dark color variations [18]. The category view differs from comparing values in that there is a standard legend that symbolizes the group or region affiliation. First, before entering the classroom, the researcher created a learning scenario with the geography teacher. Learning will be carried out for 3 weeks and every 1 week there are 2 meetings. Researchers collaborate with teachers in each meeting, the first meeting lasts 90 minutes, the teacher delivers the material at the beginning for 30–45 minutes then the next 45 minutes the researcher invites students to make a project. Project making then continues again at the second meeting.

Second, on the second day (project making meeting), each group is given time to complete the project for 90 minutes or until the lesson is over. Groups have the same sub-chapter but have different sub-themes. It is intended that each group can obtain more and broader material from groups that have different sub-themes. In Table 2, you can see the list of case studies and the coverage of areas to be studied as well as the coverage of spatial thinking concepts complete with the assessment instrument for the final project results.

In cycle 1, the sub-chapter used was the potential and distribution of industrial materials. Group 1 got the coal sub-theme, group 2 got the rubber sub-theme, and group 3 got the tobacco sub-theme. In cycle 2, the sub-chapter used was the potential and distribution of new and renewable energy. Group 1 obtained the geothermal sub-theme, group 2 obtained the water sub-theme, and group 3 obtained the log sub-theme.

Cycle 3, the subchapters used were the potential and distribution of agriculture, plantations, and fisheries for food security. Group 1 got the agriculture sub-theme, group 2 got the plantation sub-theme, and group 3 got the fisheries sub-theme.

Table 7. Project overview of Excel dynamic map charts and virtual globes

Indicator	Ability to Make Graphs	Ability to Create 2D Maps	Ability to Create 3D Maps
Case Study	Potential and distribution of coal, rubber, and tobacco for industrial materials	Potential and distribution of geothermal, hydro, and wood for new and renewable energy	Potential and distribution of agriculture, plantations, and fisheries for food security
Region	Geography of Indonesia (Kalimantan Island, Sumatra Island, Java Island) World Geography (China. Brazil, India, USA, Malawi, and Indonesia)	Geography of Indonesia (Sumatera to Java Island and Bali to Nusa Tenggara Island) World Geography (Qatar, Israel, Lebanon and Jordan)	Geography of Indonesia (Java, Sulawesi, and Sumatra) World Geography (China, Peru, Russia, USA, India, Vietnam, Japan, Malaysia, Thailand, Columbia, Nigeria, Bangladesh, Myanmar, Philippines, Pakistan, Brazil, and Indonesia)
Concept of space	Simple spatial (region) Complex spatial (scale and distribution)	Simple spatial (region) Complex spatial (scale and distribution)	Simple spatial (region) Complex spatial (scale and distribution)
Tools of representation	Excel	Excel	Excel
Reasoning process	Input (define) Processing (compare) Output (predict)	Input (define) Processing (compare) Output (predict)	Input (define) Processing (compare) Output (predict)
Instrument	Test	Test	Test
Subject	Group 1, 2, and 3	Group 1, 2, and 3	Group 1, 2, and 3

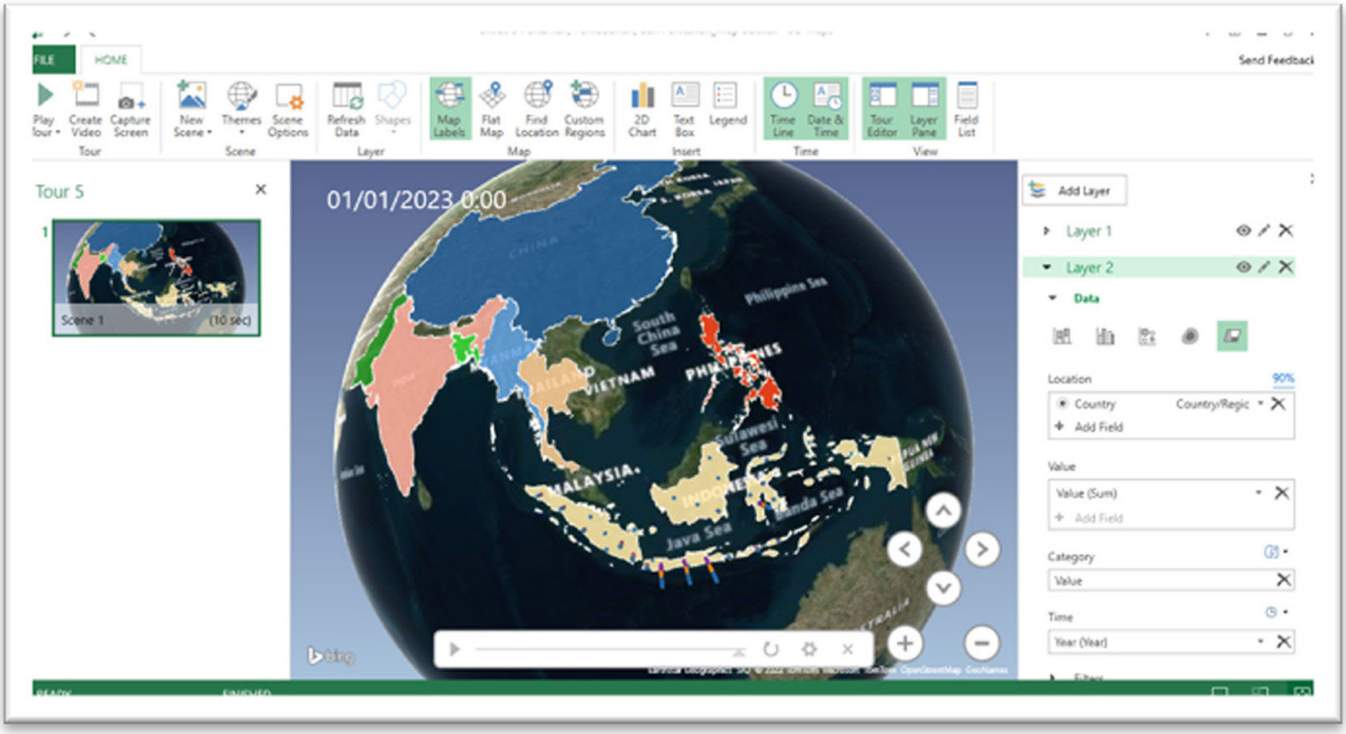

Fig. 1. The virtual globe image of Excel

Third, each group will be given learner worksheets in accordance with the predetermined sub-theme. Then learners start the process as in Table 1, namely process 1 (demand analysis). Process 1 is provided with up to date topics related to the sub theme of each group. Each group member is instructed to read the topic of the problem. Then in process 2 (analysis of alternatives), each group will be assigned to make a design and divide the tasks of each group member for problem solving. In process 3 (detailed solution analysis), members of each group begin to search and collect literature related to the sub-theme in each group.

Fourth, each member of each group can start making projects according to the sub-themes obtained. Creating this project is like process 4 (implementing and testing) as in Table 1. In this process, each group will work according to their duties. Some operate laptops, some guide the procedures for making graphical, map charts, or virtual globes, and some collect literature. Process 4 is a different process from the previous geography learning process. Process 4 this time contains the concept of spatial thinking, namely tools of representation. Learners not only use tools to represent their topic, but are also involved in making their own representation tools.

In process 4, we have prepared learner worksheets in which there are guidelines for making Excel dynamic map chart and virtual globe projects, starting from making graphical, 2D maps, and 3D maps. This guide can be accessed in the form of Google Drive in which there is a folder containing video tutorials and written guides according to the skills that will be learned in cycles 1, 2, and 3. So we no longer need to give tutorials to them in class. We do this to minimize time during the learning process. We will only give the opportunity to ask questions to all group members if there are problems during the making of the project.

Fifth, learners enter the final project such as process 5 (project packaging and sharing) in Table 1. In process 5, members of each group complete their projects and then build analytical skills (summarize what findings are obtained), and are able to make decisions (answer assessment questions). This makes learners accustomed to writing the results of their interpretation or like story mapping [20]–[22]. Each group will present the results of its analysis by displaying its representation tool (product) in front of the class. Then the other groups respond by conducting a question and answer session. Finally, each group member will take a post-test after completing the process 5. This post-test aims to see any improvements that occur in each cycle.

3 RESULTS

This section explores the development of questions through levels of thinking from Bloom's taxonomy and spatial thinking that will feed into the exploration of geography from an Indonesian and world scale through Excel dynamic map chart and virtual globe projects. Questions on Bloom's taxonomy criteria are organized according to three levels of higher order thinking/HOTS. The three levels of higher order thinking/HOTS are very helpful for sequencing the structure of questions that contain the three components of spatial thinking so that it will help build spatial thinking well. However, we found that the elements in Bloom's taxonomy and spatial thinking can be interpreted as interconnected. If there is a change in the use of the elements in the two taxonomies, there will be a change in the level of thinking in a question. This change in the level of thinking will have a range of effects on spatial thinking. Because a good spatial question is one that incorporates the three components of spatial thinking (place/location concept, tool use, and reasoning process) and not just one or two components [11].

Table 8. Number of questions based on Bloom's taxonomy and spatial thinking

Bloom's Taxonomy	Taxonomy of Spatial Thinking			Number of Questions		
	Concept of Space	Using tools of Representation	Reasoning Process	Cycle 1	Cycle 2	Cycle 3
C4-analyze	SS (region)	Use map	Input (define)	1	1	1
C5-predict	CS (distribution)	Use map	Processing (compare)	2	2	2
C5-comparing	CS (scale)	Use map	Output (predict)	1	1	1

In building a good spatial thinking in this Excel dynamic map chart and virtual globe project, we tried to test the validation of questions containing the three components of spatial thinking to a class that was not the subject of the study. This class based on the opinion of the teacher who teaches geography is included in the superior class category. All participants who are not research subjects have good abilities if given questions in the form of descriptions because geography teachers accustom them to be skilled in expressing opinions through coherent answers. In the implementation of validation trials conducted before entering the research class, it was found that there were 3 students in class XI IPS 3 who did not work on the questions. So that out of 35 students, there were 32 students who worked on it. The time for working on this question is two days because at the time of the trial, there were still some students who had not collected. In its implementation, there were twelve questions that were declared valid when tested with IBM SPSS statistics version 25 with the Pearson bivariate relationship formula.

Table 9. Validity test results of class XI IPS 3

	Question	Sum	Definition
1	Pearson Correlation	.661**	Absah
	Significant	.000	**
2	Pearson Correlation	.731**	Absah
	Significant	.000	**
3	Pearson Correlation	.686**	Absah
	Significant	.000	**
4	Pearson Correlation	.741**	Absah
	Significant	.000	**
5	Pearson Correlation	.601**	Absah
	Significant	.000	**
6	Pearson Correlation	.753**	Absah
	Significant	.000	**
7	Pearson Correlation	.464**	Absah
	Significant	.008	**
8	Pearson Correlation	.554**	Absah
	Significant	.001	**
9	Pearson Correlation	.588**	Absah
	Significant	.000	**
10	Pearson Correlation	.480**	Absah
	Significant	.005	**
11	Pearson Correlation	.707**	Absah
	Significant	.000	**
12	Pearson Correlation	.667**	Absah
	Significant	.000	**

Notes: ** Correlated if 0.01 level (2-tailed); * Correlated if 0.05 level (2-tailed).

Once the process of collecting validity test data was completed, we started testing the reliability of the questions. This reliability test was carried out because it was to measure whether the twelve questions were consistent or not in measuring the same symptoms (spatial thinking) both in the trial class and in the research subject class. This reliability test was conducted simultaneously with the validity test using IBM SPSS statistic version 25 with Cronbach's alpha method. Table 5 shows that the twelve questions tested were declared reliable because the r value was above 0.05. If seen through Table 6, it will be seen how the reliability results on each question.

Table 10. Results of reliability statistics

Cronbach's Alpha	N of Items
.869	12

Note: Cronbach's Alpha is reliable if $r > 0.05$.

Table 6 shows each question that has been declared reliable. The high and low value of reliability is called the reliability coefficient value. The reliability coefficient values that have been obtained indicate high and very high question qualifications. The criteria are concluded from the statement Jason S. Wrench, Candice Thomas-Maddox (2018) Cronbach's alpha coefficient 0.90 + is categorized as excellent, 0.80–0.90 is categorized as good, 0.70–.80 is categorized as respectable, 0.65–0.70 is categorized as minimally acceptable, 0.60–0.65 is categorized as undesirable, and 0.60– is categorized as unacceptable.

Table 11. Question reliability results

Average Scale if Removed		Scale Variation if Removed	Total Correlation	Cronbach's Alpha
Q1	25.94	19.415	.580	.857
Q2	26.16	18.975	.662	.851
Q3	26.34	19.007	.602	.855
Q4	26.06	18.319	.661	.851
Q5	26.28	19.241	.489	.864
Q6	26.44	18.577	.683	.849
Q7	26.97	20.934	.376	.868
Q8	26.50	20.000	.455	.864
Q9	26.47	19.934	.499	.862
Q10	26.00	20.839	.393	.867
Q11	26.00	19.097	.632	.853
Q12	26.03	19.322	.584	.856

Note: Cronbach's Alpha is reliable if $r > 0.05$.

3.1 Decision making: classical data analysis

The process of creating Excel dynamic map chart and virtual globe projects, which are based on the three components of spatial thinking through questions given after the project is completed (post-test), directs learners to think spatially about how they view Indonesian geography and the world scale. The lesson planning with three cycles and the target skills learned in an innovative way were able to encourage them not to be fixated on geography textbooks. Learning outcomes in the research class subject (XI IPS 1) reached the minimum completeness criteria above 75. Basically, each education has different minimum completeness criteria so that the decision making on classical completeness made by researchers followed the standards made by the school. The results of the calculation of classical completeness can be seen in Table 7.

We took the post-test results in class XI IPS 1 which became our focus. This class gets our attention because it has problems related to geography learning outcomes in the classroom. As we have revealed in the introduction, this class has a low average score of geography subjects. This class is different from the pilot class, the number of research subject participants between male and female is balanced, has diverse abilities (diligent, smart, quiet, hyperactive, and prestigious in non-academic). When the post-test was conducted, we had coordinated with the geography teacher to divide equally between groups 1, 2, and 3. We involved the teacher so that, when making projects, all group members could be active in it and complement each other's shortcomings.

When the post-test results have been presented from all cycles, all students collect simultaneously or completely with the number of participants in the class. This was different from the trial class where there were still some undisciplined learners. So this makes it easier for us to calculate the results of the classical completeness of the class that is the subject of our research. The results of the calculation using Excel can be seen in Table 7. The difference in P scores that show the standard of minimum completeness criteria above 75 in Table 7 can be seen from cycles one, two, and three.

Table 12. Calculation results of KKM

Classical Completeness (CC)	Cycle 1	Cycle 2	Cycle 3
N-CC	21	23	32
N	32	32	32
P	65,62	71,87	100

Note: nCC (number of students who scored above CC) N (number of students) P (classical completeness value).

In cycle 1 make a graphical skill project, using the subchapter of the potential and distribution of industrial materials. Overall the questions remained in accordance with Table 3 but it was found that 11 people scored below the CC.

Cycle 2 made a 2D map skill project, using the sub-chapter on the potential and distribution of new and renewable energy. Overall the questions remained in accordance with Table 3 but it was found that as many as 9 people scored below the CC.

Cycle 3 made a 3D map skill project (virtual globe), using the sub-chapter on the potential and distribution of agriculture, plantations, and fisheries for food security. Overall, the questions remained in accordance with Table 3 but no students were found who scored below the CC standard or all managed to reach the minimum completeness criteria.

4 DISCUSSION

The results of the research have informed how we implemented the Excel dynamic map chart and virtual globe project in the case study part of Indonesian Geography, as well as its application in World Regional Geography. Regarding the considerations of what we have learned and gained after doing the Excel dynamic map chart and virtual globe project: Firstly, to measure the level of spatial thinking of the learners, especially how to make Excel dynamic map chart and virtual globe project, we conducted a survey at the beginning (pretest) so that it will help us to plan and implement activities using Excel dynamic map chart and virtual globe project more efficiently at the end of the learning chapter. This pretest is useful for the purpose of comparing the learning outcomes at the end of the project when students have done the post-test. As noted by other geographers, using pre-project and post-project assessment instruments to assess competencies before and after the introduction of new curriculum innovations is common in geography education research [23]–[25].

Geography learning has its own characteristics from other subjects. Geography is always about learning and building spatial thinking. Spatial thinking is a fundamental way of thinking in geography [26]–[28]. However, spatial thinking cannot be characterized as a single skill [27]–[31]. These skills are depicted in Tables 1, 2, and 3 which show that, in the process of creating questions that lead learners to think spatially, Bloom's taxonomy contribution is necessary. Spatial thinking skills are characterized by spatial visual skills, mental rotation, penetration thinking, navigation, and recognizing patterns [6], [32]. Skills in making Excel dynamic map chart and virtual globe projects have shown validity and reliability results that are in accordance with the predetermined question standards. The validity and reliability results in Tables 4 and 5 are very illustrative of how this question has been tested valid and reliable.

The three levels of Higher Order Thinking Skill are very helpful for sequencing the structure of questions that contain three components of spatial thinking so that it will help build spatial thinking well. We found that HOTS thinking components and spatial thinking are in line with the implementation of question making and to build spatial thinking in geography subjects. The elements in Bloom's taxonomy and spatial thinking can be interpreted as interconnected elements. If there is a change in the use of elements in the two taxonomies, there will be a change in the level of thinking in a question. The creation of questions in the Excel dynamic map chart and virtual globe projects is very specific and interesting to us in our research findings. Meanwhile, as stated in [28], still use only spatial thinking taxonomy without involving Bloom's taxonomy for HOTS thinking.

We see that spatial thinking with the use of Excel dynamic map chart and virtual globe project are both inseparable and as one unit in the 3 components of spatial thinking. Excel dynamic map chart and virtual globe are visual representations in the form of maps, diagram models, and graphs. These representations are tools that serve as facilities to stimulate learners' complex reasoning in processing spatial thinking [11], [33]–[35]. Using representation tools can also help learners in organizing and linking information so that it is easier to understand and can be communicated properly. Meanwhile, the reasoning process conducted after the project (post-test) is the third component in spatial thinking. Reasoning process is related to skills that relate spatial knowledge by combining one with another along with decision making, problem solving analysis, hypothesizing, or evaluating [4].

This reasoning process is then measured by questions that have gone through validation and reliability tests. Table 7 has illustrated that the perfect reasoning process occurs in cycle 3 (3D map skill or virtual globe). Cycle 3 is the most popular cycle for learners because it is quite easy to make and very interactive compared to cycle 1 (graphical skill) and (2D map skill). Learners enjoy how the features in the 3D map work such as being able to change the theme of the globe itself, create scene options (circle, dolly, figure 8, fly over, push in, and rotate globe), create a flat map, set the time of potential changes and distribution over time, and zoom in and zoom out the location of the globe in detail. This way, students can easily do a play tour or even make a video tour.

Second, we provide learners with guidance on how to use Excel and how to create Excel dynamic map chart and virtual globe projects. The short guide "Excel_Graphical Skill Tutorial", "Excel_2D Map Skill Tutorial", "Excel_3D Map Skill Tutorial", as well as the written guide will be useful tutorials for learners to establish a basic level of knowledge about using Excel. However, we realize that the creation of this

Excel dynamic map chart and virtual globe project may be their first experience using Excel and using the features that are available.

Third, the results of classical completeness also became a benchmark for the success of implementation in each cycle. In cycle 1 graphical skill practice, we considered that we still had not achieved the success of our goal. The classical completeness score of cycle 1 in Table 8 shows a score below the minimum completeness criteria of SMAN 4 Malang. We used the standard minimum completeness criteria to adapt our research to the grading system there. Cycle 1 failed because we saw that students had difficulty in making arguments for answers related to the physical features of Indonesian Geography and its application in World Regional Geography. This is not included in the information on graphical skills, which basically only states numbers to make quantitative comparisons and conclusions. So we decided to continue the Kemmis and Taggart research procedure for replanning in cycle 2. In cycle 2, we practiced making a 2D map that can show the region of Indonesian Geography and its application in World Regional Geography. The assessment of spatial thinking still used the question development in Table 3. We conducted a post-test for cycle 2 after making the project, but we still found failure because the results of the learning completeness criteria scores were still below the average. We reflected back in accordance with the research procedure and found that this failure was due to the 2D map not representing the real appearance in the original view of the earth. The 2D map display contains regions but has color gradations that represent the different values in it. This made it difficult for learners to decipher the answer to the real appearance of each region. Finally, we made the decision to do some re-planning to prepare for cycle 3. In cycle 3, we practiced with 3D maps. The questions remained the same as the standards we had created in Table 3. The results of the minimum completeness criteria showed a big change. We concluded that the learning outcomes in cycle 3 reached the target of our goal as in Table 8. Learners achieved and even exceeded the learning completeness criteria because the 3D map helped them see the appearance of Indonesian Geography and World Regional Geography just like the real thing. We call this 3D map in Excel as virtual globe. The 3D map is able to present a combination of literacy and numeracy in spatial thinking. 3D maps make it easier for students to make real comparisons and predictions because the view presented is the same as the reality in the surrounding environment. Therefore, this is the success of our research and we conclude that questions must be adjusted to the characteristics of the tool of representation itself. As for the sub-materials we used, it did not affect the change in the tool of representation used in each cycle as shown in Table 2.

Finally, there are implications to consider in future Geography Education research. Such considerations include the creation of questions to build spatial thinking, expanding the use of Excel dynamic map charts and virtual globe and other geospatial technologies in systematic/thematic geography subjects. Although learning resources are often limited, the use of immersive virtual reality has great potential for education covering many subjects in secondary and post-secondary settings [36]. Immersive virtual reality environments "create a real and powerful sense of presence that leads to higher learner engagement and motivation" [37], [38]. The platform essentially exists on a computer through Excel and is currently releasing a new platform form Excel 365 that can be accessed through several virtual reality systems. Initial limitations in implementing the Excel dynamic map chart and virtual globe projects in the classroom were the cost of equipment for one group of learners in the classroom to access the technology, potential additional technology costs and time, and accessibility limitations [39], [40]. However, geography teachers have begun to implement the use of technology or virtual reality into the classroom. For example, [39] explains that the implementation of virtual reality in the classroom in geography subjects gives positive perceptions to students. As the use of technology has now evolved in various types of activities such as face-to-face, hybrid, and online in geography and other disciplines at the secondary level of education, the use of virtual reality in the classroom has become more and more common [41], [42]. So, there should be other perspectives in refining this research for the future especially in assessing the implementation process, increased learner success and engagement, learning processes and outcomes, and broader impacts on spatial thinking and geography literacy.

5 CONCLUSION

This article focuses on the findings from the Excel dynamic map chart and virtual globe project, through the Excel 365 platform for the Indonesian geography and World Regional Geography case studies to enhance spatial thinking and further explore active learning. Specifically, the results inform the following three categories of findings: (1) the process of creating questions to build spatial thinking can change if the selection of levels of thinking from Bloom's taxonomy is not appropriate. So, researchers must be careful in formulating the concept of questions; (2) the minimum completeness criteria for learning outcomes from each cycle increased. This finding indicates an improvement in learners' spatial thinking and mastery of using the mapping platform without the need for prior coding, software or cartography experience. This research also provides input to further adapt questions to the second concept of spatial thinking, namely the tool of representation so that tools and questions can be in accordance with the characteristics of the tool itself; and (3) Indonesian food security, industrial materials, and new and renewable energy (RE) materials, especially the case study of Indonesian and World Regional Geography used in this research, also teach students to think globally and is related to the Sustainability Development Goal.

By completing the Excel dynamic map chart and virtual globe projects, we conclude that learners: learn to create representation tools given the importance of visuals for a topic; apply spatial analysis (comparing and making predictions) to better understand the complex problem at hand and to further improve geography literacy and numeracy; learn how to tabulate information data into digital data and learn how to process existing spatial data; create maps and reason spatially thinking; and communicate this information to an audience in front of the class about their findings. The results and discussion presented from this research can be applied to geography subjects at the secondary education level, thus reinforcing the importance of incorporating the three components of spatial thinking into teaching and learning activities to build spatial reasoning and learner engagement.

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