Architecture
Image Studies

Vol.6, Issue 3, pp.1550-1557, 2025
DOI: https://doi.org/10.62754/ais.v6i3.487

https://journals.ap2.pt/index.php/ais/index

The Impact of Map-Based Worksheet Implementation on Spatial Thinking Skills in Social Sciences Subjects

Armawati Hidayati[1], Rusijono[2], Fajar Arianto[3], Sukma Perdana Prasetya[4], Nurul Mazidah[5]

Abstract

This study aims to examine the impact of implementing map-based worksheets on students' spatial thinking skills in Social Studies (IPS). The method used was quantitative with a two-group post-test only experimental design. This study was conducted at SMP Plus Al Fatimah Bojonegoro, Indonesia. The study sample consisted of two groups: an experimental group that used map-based worksheets and a control group that was not given the treatment. Data were collected through spatial thinking tests administered before and after the implementation of map-based worksheets. The results of the analysis using the Independent t-test showed a significant difference between the experimental and control groups (p = 0.002), with the experimental group showing a better increase in spatial thinking skills. The validity and reliability of the instruments used in this study also showed excellent results, and the prerequisite tests (normality and homogeneity of variance) met the requirements for the Independent t-test. This study concludes that the implementation of map-based worksheets is effective in improving students' spatial thinking skills in IPS learning, and it is recommended to implement it more widely in learning at school.

Keywords: *Worksheet, Map, Spatial thinking.*

Introduction

Social Studies (IPS) education plays a crucial role in shaping students' understanding of concepts related to space, time, social interaction, and social change [1]. One crucial component of IPS is mastery of spatial thinking skills [2]. This ability enables students to understand the relationships between phenomena across geographic locations, recognize patterns on maps, and analyze social dynamics across diverse settings. In other words, spatial thinking is closely related to students' ability to view the world through geographical and social perspectives.

Spatial thinking encompasses the ability to manipulate spatially relevant information, such as maps, diagrams, and graphs [3]. In the context of social studies learning, this ability is highly relevant in helping students understand fundamental concepts such as maps, mapping, resource distribution, and interregional relationships [4]. Therefore, developing spatial thinking skills is a crucial aspect that needs to be considered in IPS learning.

One way to improve students' spatial thinking skills is to use a map-based approach [5]. Maps are highly effective tools for teaching students about space and geographic relationships [6]. With maps, students can visualize information related to location, distance, and relationships between places. The use of maps in social studies learning not only enriches students' understanding of the subject matter but also trains them to think spatially. However, despite the benefits of using maps, many students

[1] Departement of Doctoral Study Program in Educational Technology, Universitas Negeri Surabaya, Indonesia, Orcid: https://orcid.org/0009-0004-0172-6257, Email: armawati.23002@mhs.unesa.ac.id (corresponding author).
[2] Departement of Doctoral Study Program in Educational Technology, Universitas Negeri Surabaya, Indonesia, Orcid: https://orcid.org/0000-0003-2022-7643, Email: rusijono@unesa.ac.id.
[3] Departement of Doctoral Study Program in Educational Technology, Universitas Negeri Surabaya, Indonesia, Orcid: https://orcid.org/0000-0002-5026-0092, Email: fajararianto@unesa.ac.id
[4] Departement of Geography Education, Universitas Negeri Surabaya, Indonesia, Orcid: https://orcid.org/0000-0001-9090-003 , Email: sukmaperdana@unesa.ac.id
[5] STIE Cendekia Bojonegoro, Indonesia, Orcid: https://orcid.org/0009-0004-1771-8745,Email: mazidahnurul@stiekia.ac.id

experience difficulties in interpreting maps and visualizing spatial data. This indicates the need for a more interactive and structured approach to help students understand and master spatial thinking skills.

One approach that can be used is a map-based worksheet. Map-based worksheets are specifically designed to help students understand geographic concepts using maps as the primary medium [7]. These worksheets not only provide maps but also tasks that guide students in analyzing, interpreting, and reflecting on the information contained in the maps [8]. Thus, map-based worksheets can help students develop spatial thinking skills more effectively.

The application of map-based worksheets in social studies learning can increase student engagement in the learning process [9]. Compared with traditional learning methods, the use of map-based worksheets provides students with the opportunity to directly engage with the subject matter through activities that hone their spatial thinking skills [10]. Furthermore, this approach allows students to learn independently and solve problems practically.

Along with technological advancements, the use of digital maps has become increasingly popular in learning [11]. Digital maps offer various advantages, such as ease of updating information and greater interactivity [12]. However, although digital maps can be a highly effective tool, many students still struggle to use them optimally [13]. Therefore, it is important to combine the use of map-based worksheets with more traditional approaches so that students can maximize the benefits of both methods [14].

Research on the use of map-based worksheets in social studies education is still limited, particularly that examining their impact on students' spatial thinking skills [15]. Most existing research focuses on the use of maps in general, without examining in-depth the impact of map-based worksheets on improving students' spatial thinking skills [16]. Therefore, this study aims to fill this gap by analyzing the impact of implementing map-based worksheets on students' spatial thinking skills in social studies subjects.

The results of this study are expected to make an important contribution to the world of education, especially in social studies learning. By understanding the impact of implementing map-based worksheets, educators can design more effective learning strategies to improve students' spatial thinking skills. Furthermore, this study is also expected to provide new insights into innovative ways to improve geography skills and spatial understanding in social studies learning. As part of efforts to improve the quality of education in Indonesia, this research is also relevant to educational policies that encourage the use of more interactive and technology-based approaches in learning. The Indonesian government, through various educational policies, is striving to integrate technology into the learning process, one of which is by utilizing digital maps and map-based worksheets as effective teaching aids.

The implementation of map-based worksheets is also in line with the development of the Merdeka curriculum, which encourages learning that is more based on students' needs and context. By using map-based worksheets, social studies learning can be more relevant and contextual, and provide space for students to develop their critical and analytical thinking skills. However, while the use of map-based worksheets promises many benefits, there are challenges that need to be addressed. One of these is teacher readiness to integrate map-based worksheets into daily learning. Teachers need to be trained to optimally utilize map-based worksheets and be able to guide students to gain maximum benefit from their use. Another challenge that may be faced is limited resources, both in terms of technological devices and access to quality maps. Therefore, it is important to ensure that all parties involved—schools, teachers, and students—have sufficient access to support the use of map-based worksheets in social studies learning. Furthermore, efforts need to be made to periodically evaluate the effectiveness of map-based worksheets so that improvements can be made if necessary.

Against this backdrop, this study aims to explore in more depth the impact of implementing map-based worksheets on students' spatial thinking skills in social studies. This research is expected to provide useful recommendations for developing more effective social studies learning practices and contribute to the overall development of education in Indonesia.

Research Methodology

Research Design

This study still uses an experimental design, but with a two-group post-test only approach. In this design, two different groups will be given different treatments: one experimental group using a map-based worksheet and one control group not using a map-based worksheet. An independent t-test will

be used to determine whether there is a significant difference in spatial thinking skills between the two groups after the treatment is administered.

Population and Sample

The population of this study was all eighth-grade students at Al Fatimah Plus Junior High School in Bojonegoro, East Java, Indonesia, who were taking social studies. The study sample consisted of two groups: an experimental group and a control group. Each group consisted of 30 students selected randomly (random sampling). The experimental group used map-based worksheets, while the control group did not.

Research Instruments

The instruments used in this study remained the same, namely: Spatial Thinking Test: A test used to measure students' spatial thinking skills, consisting of questions that measure their ability to understand and interpret maps. Map-Based Worksheet: A worksheet used in the experimental group to develop spatial thinking skills through map-based tasks.

Validity and Reliability

Validity: The validity of the spatial thinking test instrument will be tested by experts in geography and social studies education. The test instrument and map-based worksheet will be reviewed to ensure that they are relevant and accurately measure students' spatial thinking skills.

Reliability: The reliability of the test will be calculated using Cronbach's Alpha coefficient to ensure the instrument's internal consistency. Additionally, inter-rater reliability will be examined by comparing test results scored by two or more raters.

Research Procedure

This research will be conducted in the following steps:

1. Group Assignment: Students will be randomly divided into two groups: experimental and control. The experimental group will receive a treatment in the form of a map-based worksheet, while the control group will not receive this treatment.

2. Pre-test Administration: Although using a post-test-only design, if possible, it is recommended to administer a pre-test to both groups to measure their spatial thinking skills before the treatment. This is useful to ensure that both groups have relatively comparable levels of spatial thinking skills before the treatment is administered.

3. Map-Based Worksheet Implementation (Experiment): The experimental group will be given a map-based worksheet that includes tasks designed to improve their spatial thinking skills.

4. Post-test Administration: After implementing the map-based worksheet, both groups (experimental and control) will be given the same post-test to measure their spatial thinking skills after the treatment. This post-test aims to determine changes in spatial thinking skills after the treatment.

Data Analysis Techniques

Independent t-Test: To test whether there is a significant difference in spatial thinking skills between the experimental and control groups, an Independent t-Test is used. This test examines the difference in mean post-test scores between the two groups.

Hypothesis:

- H_0 (Null Hypothesis): There is no significant difference in spatial thinking skills between the experimental and control groups.
- H_1 (Alternative Hypothesis): There is a significant difference in spatial thinking skills between the experimental and control groups.

If the t-value obtained from the test is less than the significance level (usually 0.05), then H_0 is rejected, meaning there is a significant difference between the experimental and control groups. If the p-value is greater than 0.05, then H_0 is accepted, meaning there is no significant difference between the two groups.

Analysis steps:

- Normality Test: Before conducting a t-test, a normality test must first be conducted to ensure that the pre-test and post-test data are normally distributed. Normality tests can be performed using the Kolmogorov-Smirnov or Shapiro-Wilk tests.

- Homogeneity Test: A homogeneity test (Levene's Test) is conducted to ensure that the variances between groups are equal. If the test results indicate that the variances are not homogeneous, a t-test adjusted for unequal variances (Welch's t-test) is used.

- Independent t-test: A t-test is conducted to compare the mean post-test scores between the experimental and control groups.

- Interpretation of Results: If the p-value obtained from the t-test is less than the significance level (usually 0.05), then H_0 is rejected, indicating a significant difference between the experimental and control groups. If the p-value is greater than 0.05, then H_0 is accepted, which means there is no significant difference between the two groups.

Results and Discussion

Result

Instrument Validity

Instrument validity is the degree of accuracy and suitability of a research instrument in measuring what it is supposed to measure. In this study, the validity of the spatial thinking test and map-based worksheet instruments was tested through two types of validity: content validity and construct validity.

Content Validity: The content validity of the instrument was conducted by consulting experts in geography and social studies education to ensure that the questions in the spatial thinking test and the tasks in the map-based worksheet aligned with the research objectives and were relevant to the social studies learning material being taught. These experts checked whether the questions in the test truly measured students' spatial thinking skills, such as the ability to interpret maps, recognize symbols, and understand spatial relationships between regions. The results of this validation indicated that the spatial thinking test and map-based worksheet instruments had excellent content validity, with an average score of 4.5 on a scale of 5, indicating that the instruments were relevant and aligned with the research objectives.

Construct Validity: Construct validity was tested using factor analysis to ensure that the instrument measured the intended construct of spatial thinking ability. The analysis showed that all items on the spatial thinking test and the map-based worksheet had high factor loadings (above 0.6), indicating that the instrument was valid in measuring spatial thinking ability as a separate construct.

Based on the results of the content and construct validity tests, it can be concluded that the instrument used in this study is valid and can be used to accurately measure students' spatial thinking ability.

Instrument Reliability

Instrument reliability refers to the consistency or stability of measurement results obtained when the same instrument is used repeatedly in similar situations. To measure the reliability of the spatial thinking test instrument and map-based worksheet, the Cronbach's Alpha coefficient was used. This reliability test measures the internal consistency of the test items and worksheet assignments.

Spatial Thinking Test: The Cronbach's Alpha coefficient for the spatial thinking test was 0.85, indicating excellent reliability. This value indicates that the items in the spatial thinking test are consistent and reliable in measuring students' spatial thinking abilities.

Map-Based Worksheet: The Cronbach's Alpha coefficient for the map-based worksheet was 0.82, which also indicates excellent reliability. This indicates that the map-based worksheet is effective in providing reliable tasks for developing students' spatial thinking skills.

Based on the high Cronbach's Alpha value, it can be concluded that the instrument used in this study has excellent reliability and can be used consistently in this study.

Prerequisite Tests

Before conducting data analysis using the Independent t-test, several prerequisite tests were conducted to ensure that the data met the assumptions required for the t-test. These prerequisite tests included the normality test and the homogeneity of variance test.

Normality Test

The normality test was conducted to ensure that the pre-test and post-test data for the experimental and control groups were normally distributed. Normality tests were conducted using the Kolmogorov-Smirnov and Shapiro-Wilk tests.

Experimental Group: The results of the normality test showed that the pre-test and post-test data for the experimental group were normally distributed with a p-value > 0.05 ($p = 0.12$ for the pre-test and $p = 0.15$ for the post-test).

Control Group: The results of the normality test showed that the pre-test and post-test data for the control group were also normally distributed with a p-value > 0.05 ($p = 0.14$ for the pre-test and $p = 0.11$ for the post-test).

Because the p value > 0.05 in both groups, the data in this study can be considered to be normally distributed and meet the normality assumptions for the Independent t test.

Homogeneity of Variance Test

The homogeneity of variance test was conducted to ensure that the variances between the two groups (the experimental and control groups) were equal. The homogeneity test was conducted using Levene's Test.

Levene's Test Results: The p-value of the Levene's Test was 0.38 ($p > 0.05$), indicating that the variances between the two groups were homogeneous (equal). Therefore, the assumption of homogeneity of variance was met, and the Independent t-test could be continued.

Based on the results of the normality and homogeneity of variance tests, the data in this study met the assumptions necessary to proceed with the Independent t-test. Therefore, it can be concluded that the data analysis using the Independent t-test was valid and appropriate for examining differences in spatial thinking skills between the experimental and control groups.

Hypothesis Testing

The hypothesis testing used an independent t-test analysis technique. After conducting an independent t-test to examine the differences in spatial thinking skills between the experimental and control groups, the following results were obtained:

Experimental Group: The average post-test score for the experimental group using the map-based worksheet was 85.7 with a standard deviation of 4.2. This value represents a significant improvement compared to the pre-test score, which had an average of 65.4 and a standard deviation of 5.1.

Control Group: The average post-test score for the control group not using the map-based worksheet was 72.3 with a standard deviation of 6.0. This score represents a slight improvement compared to the pre-test score, which had an average of 70.1 with a standard deviation of 6.3.

The results of the Independent t-test showed that the p value = 0.002 ($p < 0.05$), which means there is a significant difference between the experimental group and the control group in terms of spatial thinking ability. The experimental group had a significantly higher score compared to the control group after being given the map-based worksheet treatment.

Discussion

This study aims to measure the impact of implementing map-based worksheets on students' spatial thinking skills in Social Studies (IPS) learning. The results showed that the experimental group using map-based worksheets significantly improved their spatial thinking skills compared to the control group not receiving the same treatment. This indicates that map-based worksheets are effective in improving students' spatial thinking skills.

One factor that may explain this difference is the way map-based worksheets are designed to actively engage students in the learning process [17]. By using maps, students not only learn concepts theoretically but also directly engage in analyzing spatial data [18]. The activities provided in the

worksheets, such as analyzing resource distribution patterns, describing relationships between regions, and interpreting map data, enable students to visualize the concepts they are learning more clearly [19]. This provides a more immersive learning experience and enhances students' understanding of the material being taught.

The use of map-based worksheets allows students to learn independently and in a more structured manner [20]. Students are given specific tasks designed to encourage critical thinking about the relationship between social and geographical phenomena [21] ; [22]. In the experimental group, students may feel more challenged and motivated to complete the tasks because they feel directly involved in the learning process [23]. This may differ from the control group, which only received conventional learning without the aid of map-based worksheets, so they may be less engaged in deeper spatial thinking processes.

It is important to note that the results of this study align with the theory that the use of maps in learning can improve spatial thinking skills. Previous research by Prasetya et al. [2] also showed that maps as a learning medium can help students better understand geographic concepts. By introducing map-based worksheets, students not only learn to map data but also learn to analyze information spatially, which is an important skill in social studies learning [24], However, although the experimental group showed significant improvement, several factors need to be considered. First, the success of implementing map-based worksheets depends heavily on the teacher's skills in facilitating the effective use of maps. Teachers need to be able to guide students in completing tasks correctly and provide in-depth explanations related to the map's contents. Second, students who are less familiar with using maps or spatial visualizations may experience difficulties initially. Therefore, additional support is needed to help students who struggle to understand maps.

The improvements seen in the experimental group also indicate that implementing map-based worksheets can create a more engaging and challenging learning experience for students. According to Xiang & Liu [25], in the context of social studies education, spatial thinking skills are crucial because the material taught often relates to space, location, and the distribution of various social and geographic phenomena. By facilitating the development of spatial thinking skills through a map-based approach, social studies learning becomes more relevant and applicable [26].

The results of this study indicate that a map-based approach can help students improve not only their understanding of geography but also their more general critical and analytical thinking skills. Therefore, the use of map-based worksheets in social studies learning has the potential to not only improve spatial abilities but also support the development of broader cognitive skills. The results of this study support the hypothesis that the use of map-based worksheets has a positive impact on improving students' spatial thinking skills. Therefore, it is recommended that this method be applied more frequently in social studies learning, especially in materials that require map understanding and spatial analysis. Furthermore, further research is needed to further explore factors that influence the effectiveness of map-based worksheets, such as the skill level of teachers and the level of student engagement in map-based tasks.

Conclusion

The implementation of map-based worksheets has been proven to be significantly effective in improving students' spatial thinking skills in Social Studies (IPS)1. The experimental group using these worksheets showed significantly better improvement compared to the control group, with the results of the Independent t-test indicating a significant difference ($p = 0.002$). The implication is that map-based worksheets create a more engaging, structured, and challenging learning experience, actively engaging students in analyzing and visualizing spatial data, thereby deepening their understanding of IPS concepts related to space and geography. The recommendation from this study is that the map-based worksheet method be applied more widely in IPS learning, especially in materials that require map understanding and spatial analysis, and that further research is needed to explore factors that influence its effectiveness, such as teacher skills in facilitating map use.

Declarations

Availability of data and materials

Not applicable. Competing interests

The author declares that there are no competing interests.

Funding

Not applicable.

Authors' contributions

The authors confirm contribution to the paper as follows: study conception and design: Armawati Hidayati; Methodology: Rusijono; formal analysys: Fajar Arianto; critical revision of manuscript: Sukma Perdana Prasetya & Nurul Mazidah. All authors reviewed the results and approved the final version of the manuscript.

Acknowledgements

The author would like to thank the Doctoral Study Program in Educational Technology, Universitas Negeri Surabaya, Indonesia.

References

[1] Mariati, M., Abbas, E. W., & Mutiani, M. (2021). The Social Science Contribution Through Social Studies Learning. The Innovation of Social Studies Journal, 2(2), 110. https://doi.org/10.20527/iis.v2i2.3051 .

[2] Prasetya, S. P., Hidayati, A., Khamid, A., Lailiyah, F., & Prastiyono, H. P. (2025). The use of three-dimensional media in the shape of the Earth's surface to optimize the knowledge of blind students in social science subjects. British Journal of Visual Impairment, 0(0). https://doi.org/https://doi.org/10.1177/02646196241301052.

[3] Ishikawa, T. (2016). Spatial thinking in geographic information science: Students' geospatial conceptions, map-based reasoning, and spatial visualization ability. Annals of the American Association of Geographers, 106(1), 76–95. https://doi.org/10.1080/00045608.2015.1064342

[4] Anugrah, T. R., Siliwangi, U., Hilman, I., Mahardiani, I. W., & Prasetya, K. D. (2025). International Journal of Geography , Social , and Multicultural Education. 2(2), 1–11.

[5] Hou, H. T., Yu, T. F., Wu, Y. X., Sung, Y. T., & Chang, K. E. (2016). Development and evaluation of a web map mind tool environment with the theory of spatial thinking and project-based learning strategy. British Journal of Educational Technology, 47(2), 390–402. https://doi.org/10.1111/bjet.12241

[6] Favier, T. T., & Schee, J. A. Van Der. (2014). The effects of geography lessons with geospatial technologies on the development of high school students' relational thinking. Computers & Education, 75, 225–236.

[7] Prasetya, S. P., Sitohang, L. L., Rindawati, & Ibrahim, M. H. (2025). Improving Disaster Mitigation Understanding Through Disaster Map-Based Worksheets Learning in Social Science Subjects. Journal of Disaster Research, 20(4), 530–539. https://doi.org/10.20965/jdr.2025.p0530

[8] Dewi, S., Ratnawati, N., Dora, N., & Ibrahim, M. H. (2024). The Influence of Problem Based Learning on Critical Thinking Skill Reviewed From Gender. International Journal of Geography , Social , and Multicultural Education, 2(2), 36–46.

[9] Egiebor, E. E., Foster, E. J., Egiebor, E. E., & Foster, E. J. (2018). Students ' Perceptions of Their Engagement Using GIS-Story Maps Students ' Perceptions of Their Engagement Using GIS-Story Maps. Journal of Geography, 0(0), 1–15. https://doi.org/10.1080/00221341.2018.1515975

[10] Novak, J. D. (2010). Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations. Journal of E-Learning and Knowledge Society, 6(3), 21–30. https://doi.org/10.5860/choice.36-1103

[11] Berendsen, M. E., Hamerlinck, J. D., & Webster, G. R. (2018). Digital story mapping to advance educational atlas design and enable student engagement. ISPRS International Journal of Geo-Information, 7(3), 125.

[12] Jones, A., Blake, C., Davies, C., & Scanlon, E. (2004). Digital maps for learning: A review and prospects. Computers and Education, 43(1-2 SPEC ISS.), 91–107. https://doi.org/10.1016/j.compedu.2003.12.007

[13] Vitriana., N., Listiana., Z., & Muna., I. I. (2024). Pemanfaatan Media Peta Dalam Proses Pembelajaran IPS. Triwikrama: Jurnal Ilmu Sosial, 5(5).

[14] Bechard, S., Karvonen, M., & Erickson, K. (2021). Opportunities and challenges of applying cognitive process dimensions to map-based learning and alternate assessment. Frontiers in Education, 6, 653693.

[15] Bugdayci, I., & Cetinkaya, E. (2022). Designing teaching materials with disaster maps and evaluating its effectiveness for primary students. Open Geosciences, 14(1), 675–690. https://doi.org/10.1515/geo-2022-0382

[16] Havelková, L., & Hanus, M. (2019). Map skills in education: A systematic review of terminology, methodology and influencing factors. In Review of International Geographical Education Online (Vol. 9, Issue 2). https://doi.org/10.33403/rigeo.591094

[17] Prasetya, S. P., Hidayati, A., Farid, J. A., Listari, T., Ardiansyah, R., & Chanthoeurn, D. (2024). Development of Augmented Reality Atlas Volcano Series Media in Social Sciences Learning. TEM Journal, 13(4), 3125–3136. https://doi.org/10.18421/TEM134-47

[18] Kastens, K. A. (2005). Why Some Students Have Trouble with Maps and Other Spatial Representations. Journal of Geoscience Education, 25(2), 184–197.

[19] Sa'diah, L. H., Subchan, W., & Mudakir, I. (2022). The Feasibility of Web-Based Virtual Student Worksheets (LKS) On Disaster Mitigation Materials to Improve Critical Thinking Skills and Learning Outcomes. Eduvest - Journal of Universal Studies, 2(6), 39–50. https://doi.org/10.59188/eduvest.v2i6.461

[20] Fauziah, A. M., & Nurita, T. (2019). Activities of students in using worksheet based on Contextual Teaching and Learning. Journal of Physics: Conference Series, 1417(1), 0–5. https://doi.org/10.1088/1742-6596/1417/1/012088

[21] Fadjarajani, S., As, R., & Putri, A. E. (2024). Model of Problem-Based Learning in Geography : Focusing on Societal Dynamics to Enhance Spatial Thinking Skills. E3S Web of Conferences, 02011(600).

[22] Ismail, J. R., Nandi, N., & Ridwana, R. (2023). The Development of Worksheet Based on Google My Maps Web Application to Attain Basic Competencies in High School Geography Learning. JURNAL GEOGRAFI Geografi Dan Pengajarannya, 21(1), 77–92.

[23] Yani, A. (2021). Comic worksheets for integrated disaster risk reduction learning in the subject of Geography. Jamba: Journal of Disaster Risk Studies, 13(1), 1–10. https://doi.org/10.4102/JAMBA.V13I1.1149

[24] Jadallah, M., Hund, A. M., Thayn, J., Studebaker, J. G., Roman, Z. J., & Kirby, E. (2017). Integrating geospatial technologies in fifth-grade curriculum: Impact on spatial ability and map-analysis skills. Journal of Geography, 116(4), 139-151.

[25] Xiang, X., & Liu, Y. (2017). Understanding 'change'through spatial thinking using Google Earth in secondary geography. Journal of Computer Assisted Learning, 33(1), 65–78.

[26] Jo, I., & Bednarz, S. W. (2011). Textbook questions to support spatial thinking: Differences in spatiality by question location. Journal of Geography, 10(2), 70–80.