Integrating GPS Data from Strava Combined with Field Experience to Develop Contour Map Reading Skills and Spatial Thinking Competence for students in Geography Teacher Education programs

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ABSTRACT: *In the context that the integration of digital technologies in geography education is becoming an inevitable trend, the development of effective approaches to enhance contour map interpretation and spatial thinking competence is an urgent requirement. This research focuses on the integration of Strava-derived GPS data with field-based experiential learning to optimize the process of teaching and learning topographic map skills for students in Geography Teacher Education programs. By utilizing Strava-derived geospatial data to capture trajectory, elevation, and movement patterns, combined with real-world field experience, the study develops a learning framework based on trajectory data, topographic maps, and digital elevation models. The results of the experiment show that this approach enables learners to accurately interpret terrain features, analyze slope characteristics, and effectively connect map representations with real-world spatial experience. The proposed approach is expected to serve as an innovative pedagogical model, contributing to improving the quality of geography education and fostering higher-order spatial competencies in the context of digital transformation.*

KEYWORDS: *Contour map, spatial thinking competence, Strava-derived geospatial data, experiential learning, topographic map skills.*

I. INTRODUCTION

Topographic map reading skills, especially contour line interpretation, play a fundamental role in natural geography training and research. Through the contour line system, learners can identify terrain morphology, analyze slopes, slope directions and geomorphological features, thereby serving many fields such as territorial planning, resource management or natural disaster research. Studies have shown that topographic map analysis not only helps to determine geomorphological features but also has implications in practical applications such as volcanic stratigraphic studies or geothermal mining [1]. In addition, the exploitation of elevation data from digital elevation models (DEMs) also allows for the inference of many important terrain attributes [2], [3].

However, in the practice of teaching geography, the skill of reading contour maps is still one of the contents that poses challenges to learners. The transition from map notation to three-dimensional spatial visualization requires a high level of spatial cognition ability, while many students are limited in this skill [4]. Studies on geography education show that learning to read maps often lacks visual intuitiveness and real-world integration, leading to low learning effectiveness [5]. Even when applying repetitive or adaptive training methods to improve cognitive competencies, learners still struggle with a lack of practical experience [6].

In this context, innovative approaches based on technology have been implemented to support the development of map reading skills. The application of tools such as Google Earth or digital maps has shown certain effectiveness in improving the ability to understand topography and geomorphological concepts [7], [8]. At the same time, augmented reality (AR) technology is also being studied as a digital learning environment that helps develop spatial thinking and map reading skills [9], [10]. However, some studies suggest that integrating technology without being tied to an appropriate learning context may not be noticeably effective [11]. This poses a requirement to combine technology with experiential-based teaching methods.

Experiential learning, especially in the field, is considered one of the core methods of geography education. According to Kolb's theory of experiential learning, knowledge is formed through the interaction between concrete experience and reflection [12]. Many studies affirm that field learning helps learners connect theoretical knowledge with the real environment, thereby improving their analytical and geographical thinking abilities [13], [14]. Even in the context of modern education, blended learning models still emphasize the indispensable role of field experience [15], [16].

Recently, the development of user-generated spatial data platforms has opened up a a novel approach in geography teaching. Activity tracking apps like Strava allow for the collection and display of trajectory, elevation, and terrain-related data in high detail. Data from Strava have been used in numerous studies related to spatial analysis and movement behavior [17], [18], and were initially utilized in education to improve learners' data reading and spatial awareness [19]. However, the direct application of this data in the development of contour map reading skills in geography training is still limited and has not been fully studied.

Based on the aforementioned limitations, this research was carried out with the goal of utilizing Strava-derived data combined with field experience activities to develop the skills of reading contour maps for Geography Pedagogical students. The study focuses on building a data-driven instructional process, designing appropriate exercises, and evaluating the effectiveness of improving learners' ability to read maps. Thereby, the research contributes to proposing a novel pedagogical approach in geography teaching oriented to capacity development, combining digital technology and practical experience.

The study area and geospatial characteristics are presented as follows: The study area belongs to Am Tien Cave and its vicinity in Trang An Scenic Complex, Ninh Binh province, located on the southern edge of the Red River Delta. including the central research point (Am Tien Cave) and functional linkage areas such as Hoa Lu Ancient Capital and part of Trang An – Tam Coc karst space. This area has coordinates approximately 20°14'–20°25' north latitude and 105°50'–106°05' east longitude, which is a transition zone between the low plains and the Northern limestone mountain system. A prominent feature is the tropical karst terrain developed on an ancient limestone bed, with a strong differentiation between mountain masses, enclosed valleys and underground river corridors. Am Tien Cave is located in a closed karst valley, surrounded by limestone mountains with an average elevation of 100–250 m, creating a semi-enclosed terrain space with limited access. Meanwhile, the Trang An – Hoa Lu – Tam Coc extension area forms a continuous karst system, in which valleys, caves and underground rivers form a spatial connection according to the natural network. The region's climate is tropical, with an average annual rainfall of about 1,800–2,200 mm, which plays an important role in karstification. The hydrological system is characterized by a combination of lakes in closed valleys, underground rivers in caves, and segmented surface rivers. In terms of human life, the area is an integrated space between the historical heritage of Hoa Lu Ancient Capital and the karst landscape of Trang An, as well as a strong ecotourism development area. This spatial structure creates a network of non-linear movement between attractions, which is an important basis for spatial behavior analysis using GIS and Strava data.

II. Research Methodology

The research was carried out for students of Geography Pedagogy during the field module. The study area is a low-lying hilly terrain with a marked variation in elevation, suitable for contour observation and analysis. The selection of the field environment is to ensure that learners have the opportunity to connect between map representations and actual terrain, in line with the orientation of experiential learning in geography education [13], [14]. Journey data is collected through a satellite navigation device (GPS), specifically the Garmin GPS watch. The device records information such as: Spatial coordinates; Altitude; Travel routes. This approach allows for the acquisition of real topographic data with high accuracy, similar to studies that use spatial data to analyze topographic features and movement behavior [17]. The collected data is synchronized to the Strava platform, which provides: Altitude charts, route maps, roads; Topographic map layer.

The use of digital data and online maps helps improve the ability to visualize the terrain, in line with the trend of applying digital technology in geography teaching [7], [8]. At the same time, this data can be seen as a form of user-generated spatial data, which is increasingly exploited in research and education [18]. Experiential activities are organized according to Kolb's experiential learning model, including stages: concrete experience, observation – reflection and generalization [12].

Table 1. Stages of conducting research

Stage	Activity content	Main objectives
Before the field experience	Students are instructed to use GPS devices and the Strava platform; review knowledge of topographic maps and contour line	Equip skills and background knowledge for field surveys and spatial data collection
In the field experience	Students move along the survey route; recording the journey using GPS/Strava; direct observation of topographic elements such as slopes,	Collect actual spatial data and observe topographic features in the field

	terrain forms, and landscape structures	
After the field experience	Use Strava data to re-analyze travel routes; building and comparing with topographic maps; Comparison with field observations	Spatial analysis, terrain reconstruction, and verification of results between digital and field data

This approach enhances the connection between theoretical and practical knowledge, which is consistent with studies on the effectiveness of field learning in geography education [14], [15]. The study uses two core types of exercises to develop contour map reading skills:

Table 2. Students perform two assignments

Exercises	Contents	Learning Objectives	Scientific basis/significance
Exercise 1: Terrain identification via contour	Students use topographic maps to identify basic terrain forms such as hills, valleys, and slopes through contour line analysis.	Develop the ability to read and understand maps, geographic spatial awareness and topographic symbol decoding skills.	Strengthening the capacity of cartography and spatial thinking in geography; in accordance with research and development of topographic map reading skills.
Exercise 2: Slope analysis and practical contact	Students analyze slopes based on contour density and contrast them with field travel experiences on the survey route.	Strengthen the connection between map and field representations, improve applied geographical thinking.	Enhance the integration between map data and real-world spatial sensing, supporting experiential learning.

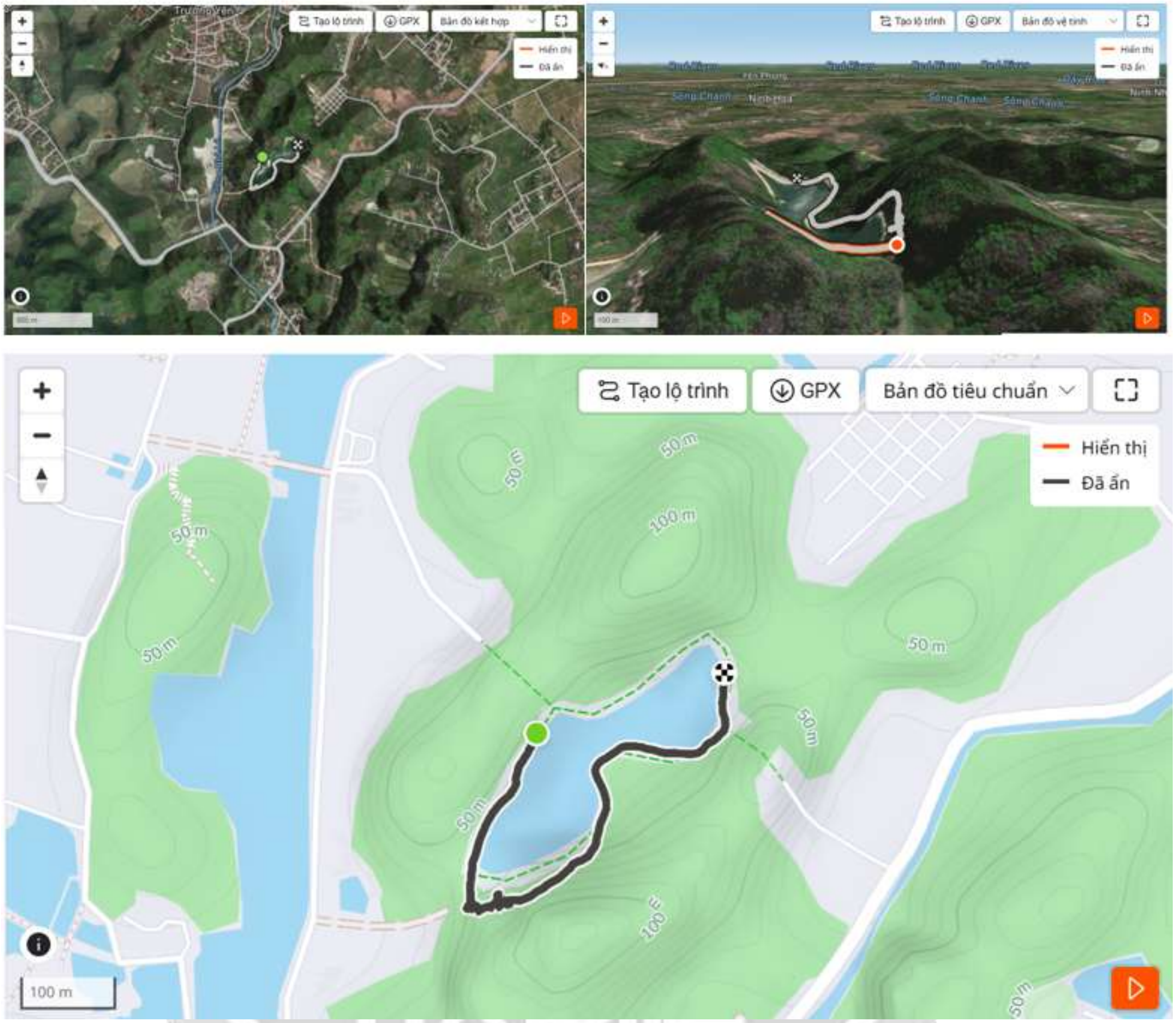

Figure 1. Strava field route and topographic representation using a contour map

The group of authors then analyzed the learning products as students' work; Observe the learning process including the level of participation and interaction; Compare before and after to assess the level of improvement in map reading skills. This approach is consistent with studies on the development of cognitive skills in map reading through practice and experience [6].

III. RESULTS OF RESEARCH AND DISCUSSION

Through the image of the field survey route (Figure 1), students carried out two learning tasks simultaneously: (i) topographic identification via contour and (ii) slope analysis combined with practical experience on the travel route.

In Exercise 1: Topographic Identification via contour line, students use a topographic map to identify basic topographic forms in the study area. Observation of the contour line system shows a clear differentiation between the low valley area (the central lake area), the surrounding slopes and the hills and limestone mountains with a relatively large altitude (50 m – 100 m). Combined with the Strava route data, students identified the trend of the route mainly following the low-lying terrain area around the lake, while limiting access to areas with dense contour lines – a manifestation of steep slopes.

For Assignment 2: Slope analysis and practical contact, students conducted a comparison of contour line density with the experience of field travel on the survey route. The results showed that the sections of the route had sparse contour line (lakeside and valley areas) corresponding to the feeling of easy movement. In contrast, sections with thicker contour toward the edge of the terrain reflect the slope area, where students note a marked change in the level of difficulty when moving.

From the results of the integration of the two exercises, it can be confirmed that students have initially formed the ability to analyze the relationship between map representation (contour lines), dynamic spatial data (Strava lines) and field experiences. The similarity between the travel route model and the topographic features shows a clear law: movement activity tends to be concentrated in low-to-gentle terrain areas, while restricted to areas with high slopes. A comparison before and after the learning process showed a significant improvement in topographic map reading and analysis skills. If at the initial stage students mainly stopped at recognizing map symbols, after the field process and analysis of Strava data, students were able to explain the connection between topography – slope – and spatial movement behavior in a logical and systematic way.

This result not only strengthens topographic map reading and interpretation skills, but also enhances spatial geographic thinking through the link between digital data and field observation. Especially in modern geography education, the exploitation of Strava data contributes to promoting the "digital field" model, in which students not only learn from direct observation but also analyze real-space data collected from the user community. This contributes to the development of learners' competencies three important groups of competencies simultaneously: (1) GIS spatial analysis capacity; (2) the ability to think systematically about the topographical and human relationship; and (3) the ability to exploit digital data in applied geographic research.

However, the study also has some limitations that need to be considered. Firstly, the accuracy of the data depends on the GPS device and the user's recording conditions, resulting in spatial errors in some complex terrain areas. Secondly, the results of topographic analysis are significantly influenced by the resolution of the DEM model, in which low-resolution DEM can reduce the ability to recognize microtopographic details. In addition, Strava data is unevenly representative due to its dependence on user groups, leading to the risk of sample bias in the analysis. Therefore, to improve the reliability and comprehensiveness of the study, it is necessary to combine Strava data with complementary data sources such as field surveys, high-resolution remote sensing images, and other background GIS data layers. The combination of multiple data sources will help enhance cross-verification and improve the quality of spatial analysis.

IV. CONCLUSION

The study shows that the integration of traditional topographic data (contour lines, topographic maps) with spatial behavior data from Strava opens up a a novel approach in modern geographic analysis, particularly in teaching and natural geographic field research. The results confirm that Strava data is capable of reflecting the spatial structure of the terrain quite clearly through the user's movement route, thereby supporting the identification of slopes, valleys, ridges, and natural travel corridors. This shows the value of big data in complementing and enriching information for traditional topographic maps. Combining GIS with behavioral data improves the efficiency of spatial analysis and creates a powerful visualization tool for geography teaching. Students not only access knowledge passively but also participate in the process of analyzing, exploiting and interpreting practical data, thereby developing spatial thinking capacity and scientific research capacity.

However, the study also has some limitations: Strava data is biased due to user dependence, uneven coverage between regions, and needs to be corrected when combined with mainstream topographic data. In the future, it is necessary to expand research in the direction of integrating multiple data sources, combining digital topographic modeling and the application of artificial intelligence to improve the accuracy of spatial analysis and support more effective field geography teaching.

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