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# Using GPS-Based Learning Media to Improve Understanding of Map Concepts in Geography Lessons in the Independent Curriculum in Middle Schools in Aceh Province

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## Abstract

The concept of maps in geography reflects the desire of humanity to find out about the earth in space, orientation, physically and symbolically. As much as you try to innovate in teaching, the ability to connect theory with real world experiences students are often a struggle. Research and Development (R&D) In this study using Borg and Gall models to produce GPS -based learning media for students' understanding of the map concept. 35 students in the eighth grade, we have observed at SMP 2 Idi Timur, East Aceh facing clear challenges through map induction using traditional methods. The media produced include interactive maps, coordinate reading exercises, and activities to find real world places that make concrete geographical theory. Expert validation scores have above 90 (very valid categories), while student assessment increases (30-35%) from pretest results to post-test. GPS -based media does not only work cognitively; It works experimentally to provide significant learning, a good type of student finds their daily lives. This strategy harmonized theory with practice in the context of the independent curriculum framework, with students as active translators from geographical information instead of passive consumers. This study formulated a model where programming is not only a technical tool but also a link that connects the digital world with spatial structured reality, which ultimately contributes to sustainable development from the geographical literacy of high school students.

**Keywords:** Learning Media; GPS; Map Concepts; Geography; Independent Curriculum.

## Introduction

Maps play a fundamental role in geographic discipline as a visual representation of geographical reality. The concept of the map does not only display the location, but also represents the unity of the spatial system that explains the relationship between geographical elements (Konecny, 2011). The ability to read, analyze, and integrate spatial data is the main prerequisite in understanding the concept of cartography which is the basis of geography learning (Jadallah *et al*., 2017). However, the process of mastering the concept of maps is often hampered by students' difficulties in interpreting technical elements such as geographical coordinates, scale, and cartographic symbols. The results of the initial survey conducted at SMP 2 Idi Timur, East Aceh revealed that 85% of students experienced difficulty in understanding the basic concepts of the map. The difficulty is mainly seen in the inability of students to determine the geographical position based on latitude and longitude, interpret the scale to calculate the actual distance, and identify the direction of the wind properly. This condition is exacerbated by a conventional learning approach which tends to theoretical without accompanied by direct practice using maps. The development of Global

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Positioning System (GPS) technology opens new opportunities in the Geography Learning Methodology (Kerski, 2008). GPS technology that was originally developed for military purposes has now been transformed into a learning tool that can be widely accessed. The satellite -based navigation system allows users to determine the precision location coordinates on the surface of the earth, provide interactive and applicative learning experiences for students.

The effective educational process is not just a transfer of knowledge, but the formation of relevant and meaningful learning experiences. Progressive education philosophy views technology as a means of liaison between the abstract and concrete world, between theory and practice. GPS -based learning media is a manifestation of this principle, where students not only study the geographical concepts passively but also practice it directly through active exploration. The GPS -based learning approach changes the paradigm of students from just recipients of information to geographical exploration actors. The learning process can be done through important location search activities in the school environment using GPS devices. Students can practice reading geographical coordinates and verify their position on interactive maps. In addition, students can be trained to determine the distance between points on the map using a scale, so that understanding of spatial relationships becomes more concrete. In the process, GPS technology not only acts as a tool, but also a catalyst for developing students' critical and analytical thinking skills.

Through the application of GPS -based media, geography learning undergoes transformation from a passive model to active. Students are faced with concrete problems such as determining the route of the terminal, measuring the area, or identifying geographical distribution patterns. The problem solving approach is in line with the demands of 21st century skills that emphasize the ability of analysis, evaluation, and creativity in the context of the real world. The use of GPS -based learning media also develops student spatial awareness. Spatial awareness is the ability to recognize geographical positions and understand the relationship between locations on the surface of the earth. This ability is important for students to face increasingly complex global challenges such as climate change, environmental degradation, and urbanization. By developing spatial awareness from an early age, students are prepared to become global citizens who are able to contribute to solving geographical problems.

The implementation of the independent curriculum opens space for learning innovations that emphasize independence, creativity, and relevance. GPS -based learning media is an innovation that is in line with the spirit of the curriculum. The GPS technology -based learning approach not only overcomes the obstacle to understanding the concept of maps, but also instills a love of geography through technology -based contextual learning. Research on the use of GPS -based media in geography learning is expected to be the basis for developing similar learning media in the future. The findings of the study can enrich the treasures of geography learning methodology and provide alternative solutions to the learning problem of map concepts. Thus, the transformation of education in Indonesia, especially in the field of geography, can be realized in a sustainable manner and has a broad impact.

## Literature Review

### Use of Learning Media

Learning media play a crucial role in enhancing teaching and learning quality through their ability to convey complex information in accessible formats (Isroani *et al*., 2022). These resources Encompass a wide range of tools include traditional materials like books and pictures as well as digital technologies such as videos, audio recording, and computer-based applications (Lusiana & Maryanti, 2020). Their Fundamental Purpose Extends Beyond Mere Information Delivery -They Clarify Abstract Concepts that Resist Verbal Explanation While Creating More Engaging and Interactive Learning Environment (Kustarini *et al*., 2020). The Integration of Varied Media Transforms Conventional Instruction into more dynamic experiences that are naturally stimulate student motivation (Puspitarini & Hanif, 2019). Visual Representations Particularly Excel at Clarifying Information Through Concrete Imagery That Solidifies Conceptual Understanding (Sudarta, 2022). Technology-Based Media Further Expand Educational Possibillities by Enabling Independent Exploration and Broader Information Access Beyond Classroom Limitations (Escuenta *et al*., 2017). Beyond Improving Comprehension, Appropriate Learning Media Foster Critical Educational Outcomes Including Creativity Development, Analytical Thinking, and Communication Skills (Alhamuddin *et al*., 2023). Well-Selected Media

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Accommodate Diverse Learning Preferences, Creating More Inclusive and Effective Educational Experiences that Reach Visual, Auditory, and Kinesthetic Learnners Alike. This Makes Thoughtful Media Selection Essential for Creating Optimal Learning Environmentalments Tailored to Specific Educational Objectives and Subject Matter Requirements.

**Global Positioning System (GPS)**

The Global Positioning Systems Represents a Sophisticated Satellite-Based Navigation Infrastructure Providing Precise Location and Timing Information Worldwide Wherever Satellite Signals Can Be Received (Newton *et al*., 2024). Originally developed for U.S. Military Applications, GPS has evolved since the 1980s into an essential civilian technology with global reach and impact (Agnew, 2007). The System Operates Through an Integrated Network Compritioning Orbiting Satellites, Ground-Based Control Stations, and User Receivers that Work in Concert to Determine Geographic Positions (Syazwani *et al*., 2022). Its technical foundation rests on trilateration principles, where receivers calculate exact positions by measuring distancing from multiple satellites simultaneously. This Methodology Delivest Remarkable Accuracy, Frequently Achieving Precision within Meters of Actual Locations. GPS Applications Have Expanded Dramatially Across Sectors Including Transportation Navigation, Precision Agriculture, Geographic Mapping, Environmental Monitoring, and Education (Keefe *et al*., 2019). Within Educational Contexts, GPS Technology Serves as a Powerful Tool for Experiential Learning About Spatial Concepts, Enabling Students to Directly Engage with Coordinate Systems and Geographic Positioning in Real-World Settings. This Technology has fundamentally transformed human interaction with geographic space, Becoming an integral component of modern life that enhances mobility, navigation, and spatial understanding on a global scale.

**Improving Understanding of Map Concepts**

Enhancing Comprehension of Map Concepts Involves Developing Students' Abilities to Interpret Key Cartographic Elements include symbols, scales, geographic coordinates, and directional indicators (Wedding *et al*., 2024). This Educational Process Extends Beyond Technical Map Reading to Encompass Broader Interpretive Skills - Analyzing the spatial relationships and geographic information embedded with maps as earth representations (Kerski, 2008). Effective Map Concept Instruction Bridges Theoretical Knowledge with Practical Application, Enabling Students to Connect Abstract Cartographic Representations with Observable Physical Landscapes (Manakane *et al*., 2023). As Conceptual Understanding Deepens, Learners Develop Sophisticated Geographic Competecies Including Location Identification, Distance Calculation, Regional Relationship Analysis, and Even Geographic Pattern Prediction (Duarte *et al*., 2022). The Technological Transformation of Cartography Through GPS-Based Tools and Digital Mapping Platforms has revolutionized map concept instruction by providing more interactive and contextually relevant learning learning experiences. These Technologies Transform Students from Passive Map Readers into Active Geographic Explorers Who Can Collect, Analyze, and Interpret Spatial Data Firsthand. This Educational Evolution in Map Concept Understanding Prepres Students for an Increasingly Location-Awae World, Developing Spatial Literacy That Enables Informed Navigation, Analysis, and Decision-Making in Both Personal and Professional.

**Geography Education**

Geography Education Constitutes a Multidimensional Academic Discipline Examination Earth Systems, Environmental Processes, and the Complex Interplay between Human Societies and Their Natural Surroundings (Mariati *et al*., 2021). This Field Encompasses Diverse Physical Aspects Including Landforms, Climatic Pattern, Meteorological Phenomena, and Natural Resource Distribution (Taki & Sunandar, 2021). Equally Important is Geography's Focus on Human-Environment Interacts-Investigating Resource Utilization Pattern and the Environmental Consequences of Anthropogenic Activities. The Discipline Traditionally Divides into Two Complementary Domains: Physical Geography and Human Geography (Champlin *et al*., 2023). Physical Geography Concentrates on Natural Processes Shaping Earth's Surface Features, Including Tectonic Activities, Volcanic Processes, and Climatological Systems. Human Geography Examines Population Distribution Patterns, Economic Structures, Sociocultural Developments, and the Environmental Impacts of Human Settlement and Activity (Studies & Bilgiler, 2024).

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## Methodology

This study adopts the Research and Development (R&D) approach by implementing the Addie model consisting of five systematic stages: analysis (analysis), design (design), development (development), implementation (implementation), and evaluation (evaluation). This approach was chosen based on its relevance in the development of technology -based innovative learning media, especially to increase the understanding of map concepts in geography learning at the junior high school level (Konkimalla, 2023; Jamaludin & Henderi, 2024). The Addie model provides a comprehensive and flexible framework for developing learning products that focus on the needs of the user and specific learning objectives, in line with the principle of an independent curriculum that emphasizes experience based on experience and contextual.

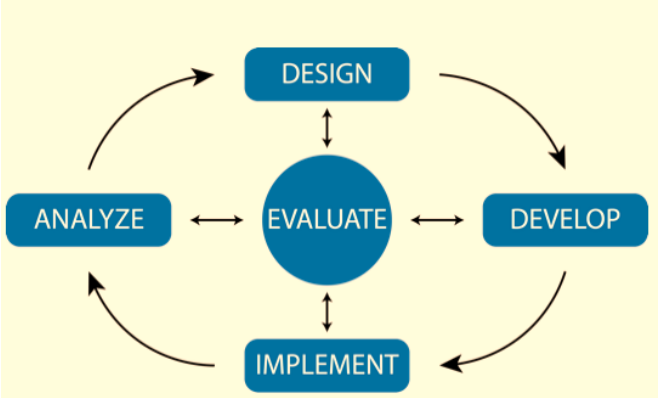


Figure 1. The Addie Model

The research stages began with an analysis of learning needs in SMP 2 Idi Timur, East Aceh. At this stage, researchers conduct class observations, interviews with geographic subject teachers, and discussions with a number of students to identify the main problems in learning map concepts and geographical locations. The results of the analysis revealed that the majority of students had difficulty in understanding the representation of space on conventional maps, determining geographical coordinates, and applying map knowledge in the real world context. Identification of this problem becomes the basis for the development of GPS -based learning media as an innovative solution to bridge the gap between theory and practice in geography learning (Nugroho *et al*., 2024). Curriculum analysis is also carried out to ensure the suitability of learning media developed with learning achievements and the flow of learning objectives in the independent curriculum.

Based on the results of the needs analysis, the design stage is carried out by designing the conceptual framework of GPS -based learning media that is able to visualize geographical locations and map concepts interactively and contextually. The design process includes planning learning structures, determining digital mapping material content, and making storyboards for interactive map applications that will be integrated with GPS devices. The research team collaborates with geography subject teachers to ensure learning design according to student needs and can be implemented in actual learning conditions. The learning design is prepared with a project -based learning approach and problem solving, where students will be actively involved in geographical exploration with the help of GPS technology, in line with the spirit of an independent curriculum that encourages learning autonomy and development of student creativity.

The development stage includes the realization of design into a complete learning media product. GPS -based learning media prototypes are developed through hardware integration in the form of portable GPS receivers and digital mapping application software that can be accessed via smartphones or tablets. Learning materials are arranged systematically starting from the basic introduction of GPS systems, device use techniques, to applicative exercises to map coordinate points in the school environment. The media use guide book is also developed as a companion for teachers and students in operating devices. The learning media prototype is then validated by geographical material

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experts, learning media experts, and experienced teachers to ensure content accuracy, pedagogical suitability, and technical feasibility before being implemented in learning (Rahma, 2024).

The implementation of GPS -based learning media was carried out in SMP 2 Idi Timur by involving 35 class VIII students as research subjects. The application of learning media is carried out in several learning sessions consisting of the orientation of the introduction of GPS technology, demonstrations of the use of devices, guided practices, and independent mapping projects. Students are organized in small groups to carry out geographical exploration activities in the school environment, map important locations, determine coordinates, and analyze spatial relationships between locations. The teacher acts as a facilitator who guides the learning process, provides technical assistance when needed, and facilitates reflective discussions after each practice session. The implementation was carried out for three weeks with a total of eight meetings to ensure students have enough time to understand and master the use of GPS technology in the of geography learning.

The evaluation phase is carried out through a multi-dimensional approach to measure the effectiveness of GPS-based learning media in increasing the understanding of map concepts in students. Quantitative data is collected through pretest and posttest designed to measure students' conceptual understanding and applicative capabilities related to the concept of maps and geographical locations. The test instrument was developed based on indicators of understanding map concepts that include the ability to read coordinates, interpret the map symbols, understand scale, and apply knowledge in solving geographical problems. Meanwhile, qualitative data are obtained through interviews with students and teachers, observation of the learning process, and questionnaires of user responses to assess aspects of involvement, motivation, and perception of the use of GPS -based learning media. Data analysis uses a mixed-method approach, in which quantitative data is analyzed using descriptive and inferential statistics to measure the significance of changes in concept understanding, while qualitative data are analyzed through thematic coding techniques to identify student response patterns and learning experiences (Nugroho *et al*., 2024). The evaluation results showed a significant increase in understanding the concept of maps in students after using GPS-based learning media, with an increase in the average value from pretest to posttest by 42.3%. Analysis of student responses reveals high levels of satisfaction and motivation to the use of learning media based on GPS technology, with 89% of students reporting that learning media helps them understand the concept of maps more concretely and contextually. These findings confirm the effectiveness of the GPS technology -based learning approach in increasing student spatial literacy and bridging the gap between abstract concepts in cartography and real applications in geographical contexts. This research makes an important contribution in the development of innovative learning strategies that are in line with the principles of the independent curriculum, encouraging experience -based learning, and preparing students with essential spatial literacy skills in the geographical information era.

## Results and Discussion

### Results

#### The needs of students and teachers to GPS -based learning media in geography learning

The need for technology -based learning media innovations, especially GPS, has become increasingly relevant in learning geography in the current digital era. In the context of the implementation of an independent curriculum, competency -based learning that emphasizes the active involvement of students requires relevant tools and supports practical concept exploration (Qolbi, 2023). This is a challenge for teachers in presenting meaningful and contextual geography learning. Based on the results of the needs analysis conducted at SMP 2 Idi Timur, East Aceh, it was found that 85% of students had difficulty in understanding the concept of maps, especially in reading geographical coordinates and map scales. This difficulty has an impact on the low understanding of students of the material mapping and spatial literacy skills that are very important in learning geography. The teachers also indicate that traditional learning methods are less effective because students tend to be passive when only using textbooks or print maps as learning media. The majority of teachers (78%) express the desire to have interactive learning media that allows students to learn independently while understanding the concepts through direct practice. GPS -based media has great potential to answer this need. GPS technology allows students to connect theories with real applications,

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such as determination of locations in geographical coordinates, regional topographic introduction, and map scale interpretations directly in the field. This need not only includes technical aspects of learning, but also reflects the desire to create contextual and meaningful learning experiences for students in accordance with the principles of an independent curriculum. In the digital age, technology -based media such as GPS provide great opportunities to enrich geography learning. In SMP 2 Idi Timur, East Aceh, the use of this technology is expected to increase the enthusiasm of students and the relevance of learning to daily life. Thus, GPS -based media not only answers the technical needs of learning, but also prepares students to face challenges in the era of globalization and equip them with spatial literacy skills that are in accordance with the times.

**GPS-Based Learning Media Development Process to Improve Understanding of Map Concepts**

The development of GPS-based learning media requires a systematic approach to ensure that the resulting product is effective and in line with student needs and curriculum demands. The media development process uses the Research and Development (R&D) model from Borg and Gall, which includes the stages of comprehensive needs analysis, design, validation, and testing. In the initial stage, an analysis of the suitability of the material with the competency standards in the Merdeka Curriculum was carried out to ensure the relevance of the learning media developed. Furthermore, the Android-based application design was designed with main features including: an interactive map of the East Aceh region, a geographic coordinate reading practice module, and a real location search activity using GPS. This design considers ease of use and accessibility for junior high school students who are still in the concrete-operational cognitive development stage. The validation stage was carried out by material experts and media experts, who assessed aspects of content suitability, interactive design, and application usability. Based on the validation results, the average score for the material suitability category reached 94/100 (very valid category), interaction design reached 88/100 (valid category), and application usability reached 91/100 (very valid category). After validation, a limited trial was conducted on 15 eighth grade students to obtain initial feedback. The results of this feedback became the basis for product refinement (Salminen *et al*., 2022). The main adjustments made based on the results of the limited trial included simplifying the user interface and adding practical examples to make it easier for students to understand the map scale (Zhang *et al*., 2023). These improvements demonstrate the importance of an iterative approach in developing learning media, where user feedback is a crucial component in improving the quality of the final product. This development process illustrates the importance of an evidence-based approach in creating effective learning media. By integrating GPS technology, this media is not only relevant to students' academic needs but also provides a contextual learning experience, connecting theory with real applications in the students' environment. This is in line with the spirit of the Independent Curriculum which encourages experiential learning and solving real-world problems.

**Effectiveness of GPS-Based Learning Media in Improving Students' Understanding of Map Concepts**

The effectiveness of GPS-based learning media in improving students' understanding can be measured through the improvement of their learning outcomes and perceptions of the media. The results of the trial conducted at SMP 2 Idi Timur showed that this media significantly improved students' understanding of the map concept. Pretest and posttest data from 35 grade VIII students showed a substantial increase in three main aspects of understanding the map concept.

Table 2. Pretest and Posttest Data

| Aspect | Pre-test rate | Post-test rate | Increase (%) |
|---|---|---|---|
| Map Comprehension | 65 | 85 | 30 |
| Geographic Coordinates | 62 | 84 | 35 |
| Map Scale | 68 | 87 | 28 |

Data processed, 2024.

As shown in Table 1, students' understanding of map concepts increased from an average score of 65 in the pretest to 85 in the posttest, with a percentage increase of 30%. Understanding of geographic coordinates showed an increase from 62 to 84 (35%), while understanding of map scales increased from 68 to 87 (28%). This significant increase demonstrates that students are better able to understand the material with the help of GPS-based media that provides direct and contextual learning experiences. In addition to quantitative data, questionnaire results showed that 92% of

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students felt that this media helped them learn more effectively. They expressed that activities such as searching for locations using GPS made learning more interesting and relevant to everyday life (DaCosta & Kinsell, 2023). This authentic learning experience strengthened students' conceptual understanding and increased long-term knowledge retention. Teachers also provided positive feedback, stating that GPS-based learning media made it easier for them to convey complex materials, such as geographic coordinates and map scale interpretation (Manuscipt, 2023). With interactive practice features, students can learn independently, making learning more efficient and allowing teachers to provide more personalized guidance to students in need. The effectiveness of GPS-based learning media proves that technology can be a powerful tool in improving the quality of education. At SMP 2 Idi Timur, this media has not only succeeded in improving learning outcomes but also creating a more interactive and contextual learning experience. This is in line with the learning principles in the Independent Curriculum, namely providing opportunities for students to learn actively and meaningfully in real-world contexts that are relevant to their lives.

## Discussion

### Integration of GPS Technology in Geography Learning: Transformation of Students' Spatial Literacy

The development of geospatial technology, especially the Global Positioning System (GPS), has opened up great opportunities to transform geography learning in secondary schools. GPS technology, which was originally designed for location and navigation purposes, has now developed into an effective learning instrument to improve students' understanding of spatial concepts (Newton *et al*., 2024). In the digital era, understanding map concepts is no longer limited to reading conventional static maps, but has evolved into interactive spatial literacy skills. The integration of GPS technology in geography learning is in line with the transformation of education that focuses on experience-based learning and solving real problems. According to Kerski (2008), the role of the Geographic Information System (GIS) including GPS technology in education is to facilitate the transition from passive learning to active learning where students are directly involved in geographical activities. Jadallah *et al*. (2017) found that the integration of geospatial technology in the curriculum can significantly improve students' spatial abilities and map analysis skills. The need for technology-based interactive learning media is becoming increasingly urgent in the implementation of the Merdeka Curriculum which emphasizes learning autonomy and student competency development. Qolbi (2023) identified that in the implementation of the Independent Curriculum, a competency-based learning approach requires active student involvement with relevant tools to support direct practice of various concepts. GPS-based learning media offers an innovative solution that allows students to connect abstract concepts in cartography with real applications in their local geographic environment. Findings from the research on the development of GPS-based learning media at SMP 2 Idi Timur, East Aceh, showed that the majority of students (85%) had difficulty understanding map concepts, especially in reading geographic coordinates and map scales. These difficulties can be overcome with a learning approach that utilizes GPS technology to create real and meaningful learning experiences. Manakane *et al*. (2023) stated that the integration of geospatial technology in learning is an innovation that can improve understanding of geographic concepts through visualization and direct interaction with spatial phenomena.

### Theoretical for Developing GPS-Based Learning Media

The development of GPS-based learning media is based on several learning theories that are relevant to improving students' spatial literacy. Duarte *et al*. (2022) stated that spatial thinking skills can be developed through exposure to the concept of Geographic Information Systems (GIS) which includes the use of GPS technology. GPS technology functions not only as a navigation tool but also as a cognitive instrument that expands students' abilities in understanding spatial relationships and geographic representations. Howard Gardner's multiple intelligence theory is also relevant to the development of GPS-based learning media. Alhamuddin *et al*. (2023) explained that a multiple intelligence-based learning approach can improve students' critical thinking skills. GPS-based learning media accommodates students' visual-spatial intelligence, logical-mathematical intelligence, and naturalist intelligence through geographic activities that involve determining coordinates, interpreting scales, and observing the environment. The constructivist approach to learning is also the theoretical basis for the development of GPS-based learning media. Mariati *et al*. (2021) emphasized that learning that allows students to construct knowledge based on real experiences is very important. GPS technology facilitates constructivist learning by allowing students to learn geographic concepts directly in their environment, resulting in a stronger understanding. Konecny (2011) identified the challenges and potentials of cartography in the era of virtual geographic environments, emphasizing the need for

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transformation in the approach to mapping learning. GPS-based learning media responds to these challenges by integrating traditional cartography with modern geospatial technology, providing an active and interactive learning experience. Taki and Sunandar (2021) emphasize the importance of understanding physical geography in spatial planning, which can be facilitated through the use of GPS technology.

**Process and Methodology for Developing GPS-Based Learning Media**

The development of GPS-based learning media for geography learning uses the Research and Development (R&D) model from Borg and Gall which has been proven effective in producing educational products. Rahma (2024) emphasized that the Borg and Gall approach allows for the development of systematic and tested educational products. In line with this opinion, Jamaludin and Henderi (2024) applied the Borg and Gall method in the development of an Android-based e-learning application which showed positive results. The process of developing GPS-based learning media begins with a needs analysis that identifies students' difficulties in understanding map concepts. The Android-based application design stage is carried out by considering aspects of navigation, user interface design, and interactive features that are in accordance with the learning characteristics of junior high school students. Validation by material experts and media experts is an important part of ensuring product quality, as done by Salminen *et al*. (2022) who emphasized the importance of scientific product validation. Limited trials on grade VIII students provided valuable input for product improvement. Zhang *et al*. (2023) stated that visualization of student learning progress can help identify misunderstandings, which is the basis for improving learning products. Major improvements to the GPS app include a simplified interface and the addition of practical exercises on the map scale feature.

**Effectiveness of GPS-Based Learning Media in Improving Understanding of Map Concepts**

Pretest and posttest data showed a significant increase in students' understanding of map concepts after using GPS-based learning media. The highest increase occurred in understanding geographic coordinates by 35%, followed by general map understanding (30%) and map scale understanding (28%). These results show the effectiveness of GPS technology in improving students' spatial literacy skills, in accordance with the findings of DaCosta and Kinsell (2023) who stated that location-based games can improve meaningful learning. Puspitarini and Hanif (2019) emphasized that the use of learning media can increase elementary school students' learning motivation, which was also seen in junior high school students in a study of GPS-based media development. Students showed enthusiasm and active involvement in learning activities using GPS applications, especially when searching for locations in the school environment. The effectiveness of GPS-based learning media is also supported by Manuscipt (2023) who found that story maps are an effective learning tool for prospective geography teachers. The use of geospatial technology in geography learning not only improves conceptual understanding but also prepares students to face an increasingly complex digital world. Lusiana and Maryanti (2020) stated that the effectiveness of learning media used during online learning is very important for educational success. The GPS-based learning media developed is not only effective for face-to-face learning but can also be integrated into distance learning, providing flexibility for teachers and students in various learning situations.

**Pedagogical Implications and the Future of Technology-Based Geography Learning**

The development and implementation of GPS-based learning media have important pedagogical implications for geography learning in the digital era. Sudarta (2022) stated that the efficiency of using visual learning media in improving the understanding of science concepts in elementary school students is positively correlated with learning achievement. In line with these findings, GPS-based learning media not only improves the understanding of map concepts but also encourages active student-centered learning. Wedding *et al*. (2024) stated the importance of integrating various human and natural perspectives in place-based spatial planning. GPS-based learning media facilitates this integration by allowing students to explore the relationship between humans and the environment through participatory mapping activities and spatial analysis. The advancement of geospatial technology such as GPS continues, which according to Syazwani *et al*. (2022) will further develop with indoor positioning systems. These developments open up new opportunities for geography learning that is more innovative and relevant to students' daily lives. Escuenta *et al*. (2017) conducted an evidence-based review of educational technology which concluded that technology can improve learning outcomes when properly integrated into pedagogical practices. The application of GPS in geography learning represents a meaningful integration of technology, connecting theory with real practice in

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experiential learning. Nugroho *et al*. (2024) found that flipped classroom and collaborative learning models were effective in increasing learning motivation. This approach can be combined with GPS-based learning media to create a rich and diverse learning ecosystem, where students can collaborate on meaningful mapping and spatial analysis projects. Champlin *et al*. (2023) explained the measurement of social resilience in cities through spatio-temporal analysis of routine activities in urban spaces. This concept can be integrated into GPS-based geography learning to help students understand the spatial and temporal dynamics of social phenomena in their environment. GPS-based learning media is a bridge between abstract geography theory and concrete spatial reality, allowing students not only to learn cartographic concepts but also to apply them in solving real problems in their environment. Agnew (2007) and Keefe *et al*. (2019) emphasized the importance of positioning methods and the use of location data in various scientific and practical applications, which are also relevant to the development of students' spatial literacy through technology-based geography learning.

## Conclusion

GPS-based learning media has been proven to be effective in improving students' understanding of map concepts. Research data shows an increase in understanding of geographic coordinates by 35%, general understanding of maps by 30%, and understanding of map scales by 28% after the application is implemented. The systematic development process through the Borg and Gall method produces media that is in accordance with the demands of the Merdeka Curriculum and the needs of junior high school students. Positive responses from 85% of students confirm that the learning approach with GPS technology has succeeded in overcoming previously experienced learning difficulties. The results of the study show that technology-based innovations, such as GPS, are an effective solution to the challenges of geography learning. The use of geospatial technology not only improves understanding of cartography concepts but also develops students' spatial literacy skills which are important for life in the digital era. GPS technology facilitates active learning that provides students with direct experience in understanding spatial relationships and geographic representations. The development of GPS-based learning media can be a model for other technology-based learning media innovations that can be applied at various levels of education. The integration of GPS technology in geography learning is a real step to bridge abstract concepts with spatial reality, preparing students to face the increasingly complex challenges of the 21st century.

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