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Theodolite and Drone Training to Enhance the Digital Mapping Competence of Teachers and Students at SMKN 1 Lubuk Sikaping

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ABSTRACT

In the era of Industry 4.0, UAV (Unmanned Aerial Vehicles) have become key technologies used widely, not only for military operations but also for mapping, monitoring volcanic activity, and producing documentary videos. Two tools advancing rapidly and highly relevant to vocational education are drones and theodolites. Their adoption in vocational schools still lags behind, especially in rural areas, so Geomatics teachers need capacity building to update Land Surveying course materials and transfer practical skills to students. This science and technology outreach program aims to equip teachers at SMK Negeri 1 Lubuk Sikaping with foundational knowledge and skills for operating drones and theodolites, along with data analysis for aerial mapping. The training is arranged sequentially, beginning with an introduction to platforms, sensors, operating principles, and safety; continuing with field practice covering mission planning, control point acquisition, and calibration procedures; and concluding with data and video processing for construction project needs, including georeferencing, orthomosaic generation, elevation modeling, and extracting relevant measurements. The targeted outputs include scientific publications in ISSN journals or national proceedings, an activity video of about 3 to 4 minutes, and coverage in print or online media. Through this program, the gap in technology and information mastery is expected to narrow, the curriculum to become more current, and teachers' pedagogical and technical competencies to improve, particularly in structural and mapping applications. Graduates under their guidance will be better prepared to enter industry with strong spatial literacy, careful data acquisition, and a solid safety culture.

***Keywords**: Drone; Theodolite; Unmanned Aerial Vehicle; Lay-Out; Surveying.*

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INTRODUCTION

Digital mapping is the process of map creation in which data collection, processing, storage, and presentation are carried out digitally, supported by integrated hardware, software, data, methods, and personnel. In practice, data is gathered through terrestrial surveying, Global Positioning Systems (GPS), photogrammetry, and remote sensing, then processed into spatial information ready for use according to user requirements. Recent developments indicate that aerial image acquisition increasingly utilizes Unmanned Aerial Vehicles (UAVs) combined with positioning-enabled digital cameras, structured mission planning, and photogrammetric workflows; this produces overlapping imagery that can be assembled into high-precision orthomosaics and elevation models for various applications, including construction. The success of spatial model reconstruction is heavily influenced by flight and acquisition

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parameters specifically flight altitude and the percentage of longitudinal and lateral overlap with appropriate settings proven to enhance the quality of UAV-based mapping results.

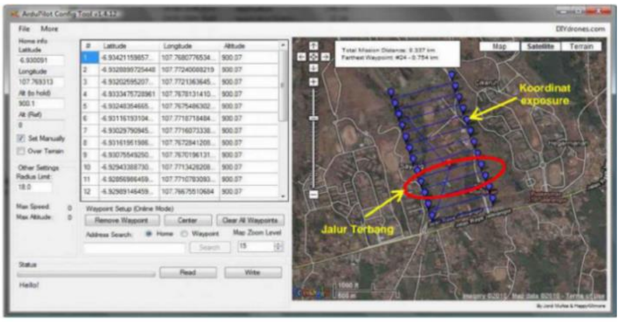

Figure 1: Flight Path Planning Process

Alongside the rapid adoption of digital mapping across various sectors, the demand for competent personnel within the vocational education ecosystem and construction projects has risen. Empirical evidence indicates a persistent gap in geospatial technology proficiency among vocational educators, highlighting the need for structured and context-specific competency enhancement programs. Addressing this need, training on theodolite operation and survey data processing for Vocational High School (SMK) teachers has been shown to improve participants' conceptual understanding and practical skills. Concurrently, drone training for SMK teachers and students has proven effective in strengthening competencies related to mission planning, data acquisition, and image processing—generating mapping products relevant to both the learning process and field operations in the construction sector. Thus, conducting theodolite and drone training for the SMK teaching community represents a strategic step toward bridging the digital mapping technology proficiency gap and enhancing graduates' readiness to meet industry demands.

Figure 2: Photography and Photo Mosaicking Process

METHOD

The implementation method was designed to ensure a clear and structured workflow for this Community Partnership Program (PKM) community service activity. Several stages are involved in this activity, including:

1. Preparation Phase

The preparation phase involves a series of activities, including contacting the Principal of SMK Negeri 1 Lubuk Sikaping as an initial step to identify partner needs and assemble the appropriate team and equipment; conducting an initial site visit and a field meeting to introduce the activities; submitting the Community Service proposal to UNP; developing an activity plan

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covering the schedule, team requirements, and equipment; preparing outreach materials—such as banners, seminar kits, technical manuals, and supporting equipment—and formally designating the community service team.

2. Implementation Stages

The training is conducted in several key sessions: theory, practice, and data analysis. This activity aims to enhance participants' skills in operating digital surveying instruments.

Session 1: Theoretical Training

The training material covers an introduction to theodolites and drones—emphasizing their respective operating principles, components, and functions—as well as an overview of measurement methods, including data acquisition techniques and pre-use calibration procedures. It also addresses the use of digital mapping software, such as GIS and AutoCAD Civil 3D, for processing the collected survey data.

Figure 3: Training on Theodolite and Drone Operations

Session 2: Simulation and Field Practice

The instrument is set up at a control point and aligned using leveling and plumb-bob principles until the vertical axis coincides with the reference point; horizontal and vertical angles, as well as horizontal and slope distances, are then measured and elevations determined using a theodolite, while a drone is utilized to acquire georeferenced aerial imagery that complements the planimetric and altimetric control.

Figure 4: Theodolite training activity.

Measurement data are systematically documented on worksheets or digital platforms, accompanied by metadata regarding time, location, and instrument configuration; accuracy is subsequently verified in the field through repeated readings, consistency and closure checks,

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and comparisons against known control points.

Figure 5: Drone training activities.

Session 3: Data Analysis and Processing of Measurement Results

Measurement data were processed using Geographic Information System (GIS) software and AutoCAD Civil 3D through stages involving preprocessing, error cleaning, datum alignment, and coordinate integration. Subsequently, the standardized data were converted into digital maps and validated elevation contour models, which were then interpreted to support planning, design, and implementation control for the construction project.

Figure 6. Processing and analysis of measurement data.

RESULTS AND DISCUSSION

The training implementation demonstrated that the entire intervention sequence—ranging from introductions to the platform, sensors, operating principles, and safety protocols, through to field-based operation of theodolites and drones and subsequent data processing using mapping software proceeded according to plan and yielded outcomes relevant to vocational education. Participants successfully prepared instruments using proper leveling and centering procedures, performed the acquisition of angular, distance, and elevation data, and integrated terrestrial measurements with aerial imagery to produce validated spatial outputs such as orthomosaics and contour models. From a pedagogical perspective, the training fostered a stronger grasp of concepts and operational skills, evidenced by the participants' growing independence in mission planning, control point establishment, calibration, and the organization of data processing workflows. Institutionally, supporting outputs—including dissemination materials, video documentation, and publication drafts provide a foundation for replicating the program and integrating the content into the Land Surveying curriculum; meanwhile, in a construction context, the utilization of the resulting data contributes to improved planning and project control quality. These findings confirm that partnerships between higher education institutions and vocational high schools (SMK) effectively bridge the gap in digital mapping technology proficiency and enhance graduate readiness to meet industry demands.

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CONCLUSION

Theodolite and drone training activities at SMKN 1 Lubuk Sikaping achieved the goal of improving participants' competencies in conceptual and procedural aspects. Participants are able to tune instruments through leveling and centring, carry out angle, distance, and elevation measurements, plan aerial data acquisition missions, and integrate terrestrial measurement results with drone imagery to produce validated orthomosaics and contour models. Supporting outputs in the form of socialization materials, video documentation, and publication manuscripts strengthen the potential for program replication and its integration into the Soil Surveying curriculum. Applicatively, the training results contribute to improving the quality of planning, designing, and controlling data-driven construction work.

The limitations of these activities include the relatively short duration of training, the variation in the topography of the location that is not yet wide, and the dependence on the availability of equipment and weather conditions. The implication of these limitations is the need for longitudinal evaluations to assess competency retention, the expansion of field practice scenarios in diverse terrain conditions, and the preparation of operational standards and uniform assessment rubrics. Follow-up recommendations include strengthening partnerships with industry for competency certification schemes, providing digital mapping mini-labs at the school level, as well as integrating spatial data-driven project assignments into routine learning. With this follow-up, the sustainability of the impact of training is expected to increase and the relevance of graduate competencies to industry needs is getting stronger.

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