Mine Surveying Technologies in Indonesia

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Abstract. The development of mine surveying technology has made major changes in mine surveying work. However, the use of mine surveying technology in developing countries is still underdeveloped. Therefore, this study aims to identify various mine surveying technologies in Indonesia based on mine surveyor perceptions and to analyse the influence of education background on the mine surveyor’ perceptions about mine surveying technologies. The study was conducted using a survey on 155 mine surveyors based on their education level. The survey was conducted using a questionnaire that has been tested for validity and reliability. Data analysis was performed using descriptive statistics and ANOVA. This study shows that there are still mine surveying technologies that are not commonly used in Indonesia, and there are significant differences in perceptions of the mine surveying technology, especially for mine surveyors graduating from senior secondary school with those graduating from diploma and undergraduate degrees.

1. Introduction

Mining is the process of extracting minerals and coals from the earth to make them available for further processing by the industry [1]. Mining techniques can be divided into two common excavation type: open-pit mining and underground mining [2]. Open pit mining is done by removing surface layers (vegetation, dirt, or bedrock) in order to reach buried minerals or coals, while underground mining is done by digging tunnels or shaft into the earth to reach buried minerals deposit [2]. The most common method to extract mineral or coal is open-pit mining [3]. This is in line with mining conditions in Indonesia, because more than 98% of mining activities are carried out using the open-pit mining technique.

Mine surveying is one of the areas of work that determines the success of mineral and coal mining activities because it provides basic information about precision positioning information for mine planning activities to all stages mining activities, which consist of exploration stage, construction stage, production stage, and rehabilitation stage [4][5]. Mine surveying activities in general are: establishment of mine surveying control network, detailed topographic surveying, data processing to calculate mined volumes and tonnages, mine monitoring deformation survey, and stake out survey [4].

Various jobs in the mine surveying cannot be separated from the mine surveyor who is in charge of carrying out all the mine surveying activities [6]. The development of technology has made major changes in mine surveying work, especially on the task of mine surveyors and the survey instrument used [7]. This is the challenge for mine surveyors to adapt through various competencies that are in line with the development of these technologies to survive [8].
Nowadays, the development of mine surveying instrument and its application rapidly growth, with the use of Electronic Total Station (ETS); and "3S" technology which stands for Remote Sensing technology, Global Navigation Satellite Systems (GNSS), and Geographic Information Systems (GIS) have been widely used in various jobs in the field of mine surveying [9]. Other technology that widely used for topographic mapping in large areas are photogrammetry survey using Unmanned Aerial Vehicle (UAV) [10] and Light Detection and Ranging (LIDAR) technology [11]. In mine monitoring deformation survey, fusion of Interferometric Synthetic Aperture Radar (InSAR) technology and GNSS in Real Time Kinematic mode are very strong complementary [9][12]. To calculate mined volumes and tonnage the laser scanner technology plays a vital role because creates dense of surface models that are photorealistic, accurate and provide a reliable platform to give accurate volume [13]. But there are problems in the mine surveying field, especially in developing countries, one of which is the use of technology that is still underdeveloped [9].

Based on the problem regarding the use of technology in the mine surveying that is still underdeveloped in developing countries, the problems investigated in this study are formulated into two research questions which is stated as follows: (1) what open-pit mine surveying technology used in Indonesia based on mine surveyor perceptions; and (2) does the level of education have a significant influence on the perception of mine surveyor in the application of the open-pit mine surveying technology. Based on the research questions, the purpose of this study is to identify various technology that are perceived important by mine surveyors in Indonesia in supporting their work based on their education levels. In addition, this study aims to picture the impact of education on the perception related to the use of mine surveying technologies. The results of the study are expected to provide information about various open-pit mine surveying technologies in Indonesia compared to various mine surveying technologies that are widely used.

2. Methods
This research was carried out using a survey method to collect data quantitatively using a questionnaire. The sample in this study consisted of mine surveyors in Indonesia who carried out open-pit mining activities. These subjects were grouped according to their level of education: senior secondary school (SSS), diploma, and undergraduate graduated. The number of samples is 155 respondents, which consisted of 82 SSS graduates, 17 diploma graduates, and 56 undergraduate graduates.

The research instrument used was a structured questionnaire. The questionnaire was developed through three stages. In the first stage, literature reviews from various journals and manual books related to mine surveying were carried out to identify various technologies in open pit mine surveying. In the second stage, the various technologies that have been identified, were reviewed by two mine surveying experts to determine their appropriateness. Based on the result of the review, there are nine mine surveying technologies. These technologies are Global Navigation Satellite Systems (GNSS) in static mode, GNSS in Real-Time Kinematic (RTK GNSS) mode, Interferometric Synthetic Aperture Radar (InSAR), photogrammetry surveys using Unmanned Aerial Vehicle (UAV), mine surveying remote sensing, mine surveying light detection and ranging (LIDAR), mine surveying spatial analysis using geographical information systems (GIS), Electronic Total Station (ETS), and Laser scanner. In third stage, the questionnaires were made based on the technologies which were identified using a 5-point Likert-type scale, with the following values: 5 = Very Important; 4 = Important; 3 = Neither; 2 = Unimportant; and 1 = Very Unimportant.

Validity content of the instrument was done through expert judgment. The results showed that the content in the instrument was relevant to what was measured. The validity of the questionnaire was examined by using the correlation analysis between the score of each item and the total score. The result indicated that all items have a favorable validity index. Reliability testing was carried out using
the Cronbach Alpha technique. The Cronbach Alpha value is 0.845. It can be concluded that the questionnaire is reliable to use in the research.

To analyze the respondents’ perceptions regarding mine surveying technology, calculations were carried out based on descriptive statistics. To be consistent with the research objectives, the mine surveying technologies that have a mean score <3.6 are categorized as unimportant, while those with a mean value of ≥3.6 are categorized as important. To see the effect of level of education of respondents on perception of mine technologies, the analysis was carried out using ANOVA.

3. Result and Discussion

3.1. Result

The mine surveying technologies perceived as important by mine surveyors of SSS graduates are ETS and GNSS in RTK Mode. The mine surveying technologies perceived as important by mine surveyors of diploma graduates are GNSS in static mode, ETS, GNSS in RTK Mode, Laser Scanner, and photogrammetry surveys using UAV. The mine surveying technologies perceived as important by mine surveyors of undergraduate graduates are GNSS in static mode, ETS, GNSS in RTK Mode, Laser Scanner, and photogrammetry surveys using UAV. Table 1 provides the mean score and standard deviation of mine surveyor perceptions based on the importance of technologies use in mine surveying.

Table 1. Mean and Deviation Standard of Mine Surveyor Perceptions of Mine Surveying Technologies

| Technology                            | SSS Mean | SSS SD | Diploma Mean | Diploma SD | Undergraduate Mean | Undergraduate SD |
|---------------------------------------|----------|--------|--------------|------------|--------------------|------------------|
| GNSS in static mode                   | 2.756    | 1.504  | 4.176        | 0.755      | 4.393              | 0.679            |
| GNSS in RTK mode                      | 3.712    | 1.363  | 4.294        | 0.985      | 4.607              | 0.679            |
| InSAR                                 | 1.817    | 1.124  | 2.412        | 1.417      | 2.268              | 1.355            |
| Photogrammetry surveys using UAV      | 1.841    | 1.212  | 3.706        | 1.490      | 3.661              | 1.443            |
| Mine surveying Remote Sensing         | 1.549    | 1.113  | 1.941        | 1.249      | 2.536              | 1.401            |
| Mine surveying LIDAR                  | 1.524    | 1.033  | 2.235        | 1.437      | 2.339              | 1.493            |
| ETS                                   | 4.683    | 0.664  | 4.824        | 0.393      | 4.625              | 0.676            |
| Mine surveying spatial analysis using GIS | 1.573    | 1.155  | 2.471        | 1.625      | 3.250              | 1.665            |
| Laser Scanner                         | 2.732    | 1.267  | 3.765        | 1.393      | 3.821              | 1.363            |

In general, based on the mean score, it appears that the technologies perceived as important by mine surveyors who graduated from SSS differed from mine surveyors with diploma and undergraduate degrees. The technologies that are perceived as important by mine surveyor graduated from SSS are less than those graduating from diploma and undergraduate degrees. This shows that mine surveyors graduated from diploma and undergraduate degrees are given more duties and responsibilities related of using of more complex technologies than mine surveyors graduated from SSS. On the other hand, technologies that are perceived as important by undergraduate mine surveyors are the same as those in diploma graduates’ perception. This shows that the graduates of diploma and undergraduate education in the field of mine surveying in Indonesia are considered to have the ability to carry out relatively the same tasks in using more complex technology.

Based on the analysis related to the effect of education levels on the respondents’ perceptions of mine surveyor competencies using ANOVA showed that at \( r = 0.05 \), all technologies had a significance value \( p <0.05 \), except in InSAR technology with \( p = 0.052 \), and ETS technology with \( p = 0.538 \). This result show that the education level had a significant impact on mine surveyor’s perceptions, except for InSAR and ETS technology. Thus, it can be concluded that the level of education has a statistically significant effect on mine surveyor perceptions regarding the technology used.
3.2. Discussion
Based on research finding, mine surveying technologies used in Indonesia are: GNSS in both static mode and RTK mode, photogrammetry surveys using UAV, ETS, and Laser Scanner. However, other technologies that have been widely used according to the literatures such as InSAR, Remote Sensing, GIS, and LIDAR have not been widely used in Indonesia. This is in line with the issues that the use of mine surveying technology in developing countries such as in Indonesia is still not optimally developed. Therefore, further studies are needed regarding what factors have led the use of mine surveying technologies in Indonesia which is still not optimally developed.

Human capital theory states that investment in education has an impact to the opportunity to get a better job [14]. This theory is used as a reference for many companies by making education as the main indicator of employees’ ability to work [15]. According to the allocation theory, work is given to employees based on competence, by providing complex work to the most competent employees, while simpler work is given to employees who are not too competent [16]. In other word, the level of education is positively related to the completion of tasks in work and tasks that are complex [17]. Based on the findings of the study, SSS graduates tend to be given less responsibilities in using mine surveying instruments compared to mine surveyors with diploma and undergraduate degrees. This is in line with the allocation theory, where employees who are considered incompetent will not be given complex tasks. This is strengthened by the results of the significance test with the finding that the mine surveying technologies that is perceived as important by SSS graduates differ significantly from the perceptions of diploma and undergraduate graduates. However, the technologies that perceived important of diploma graduates is not significantly different from those mentioned by the undergraduate graduates. These findings indicate that in Indonesia, especially in the field of mine surveying, educational backgrounds determine the assignment of tasks in jobs and occupations.

4. Conclusion
Based on finding, we can conclude that mine surveying technologies commonly used by SSS mine surveyor graduates in Indonesia are ETS and GNSS in RTK Mode. As for mine surveying technologies used by diploma and undergraduate graduates are GNSS in both static mode and RTK mode, photogrammetry surveys using UAV, ETS, and Laser Scanner. The mine surveyor’s level of education has a significant effect on their perceptions of mine surveying technologies, especially mine surveyors graduated from SSS compared to mine surveyors graduating from diploma and undergraduate degrees. However, the perceptions of diploma and undergraduate mine surveyors are not significantly different.

5. References
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