Development and Effectiveness of Drone as a Learning Media in Islamic Boarding School

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Abstract. Nowadays, drone technology is not only be used in commercial businesses but can also be utilized in a teaching-learning process, including in Islamic boarding school. This article will be discussed the development, performance, feasibility, and effectiveness of drone technology to be utilized as a learning media at Pesantren Hidayatullah Yogyakarta that is one of Islamic boarding school. The developed drone was the multicopter with a multi-rotor type using four rotors. This study was conducted with the development research approach developed by Alessi and Trollip and the descriptive research approach. This drone was applied in teaching-learning process at Pesantren Hidayatullah Yogyakarta. Data were obtained through drone’s testing and observation, interviews, questionnaires for the drone’s affectivity in teaching-learning process. The results of this study can be known that the drone performance is categorized as "Very Good" in terms of functionality and usability aspects. The drone feasibility in the term of material quality and its usefulness is included in the "Very Feasible" category. The drone as learning media has had significantly impact when it’s applied in learning process in extracurricular activities.

1. Introduction

Today's technological and scientific innovations continue to grow along with the flow of globalization to produce supporting devices. All of these technologies are highly dependent on electronic devices that require electricity to operate them. One of the rapidly developing technologies today is intelligent robot technology [1]. Intelligent robot technology has various types such as the types of land robots, water robots, and air robots. Drone or Unmanned Aerial Vehicle (UAV) is one type of intelligent robot that can be operated manually or automatically which is well known in a wider community. The development of robot technology has had many impacts and benefits in life nowadays, especially in the industrial and business sectors. The industrial and business sectors have taken advantage of the development of robotic technology to support the expansion of their activities [2] because production costs can be reduced so that product prices become cheaper and speed up a production process more efficiently [3]. In addition to the industrial and business sectors, the development of robotic technology also has an impact and benefit on an education sector.

The education sector can take advantage of this robot technology as a learning media or a learning aid to convey material in teaching and learning process activities. Learning media in the form of robots can be used to redesign a classroom atmosphere to be able to produce high-level thinking skills for students [4]. In addition, this learning media is also useful for equating students' perceptions and strengthening a material to be delivered by the teacher [5]. Besides being applied to academic learning activities, learning media in the form of robots can also be applied to non-academic learning activities,
such as extracurricular activities. The application of robots in extracurricular learning activities can foster cognitive skills and teamwork so that students can express ideas that are valuable for their lives in the future [6]. Therefore, this robot technology, such as a drone, can be designed to be used as a learning media in schools.

Pesantren or Islamic Boarding School Hidayatullah Yogyakarta is one of an educational institution that organizes religious and general science-based learning activities that provide at the levels of Madrasah Ibtidaiyah level, which is equivalent to an elementary school, Madrasah Tsanawiyah which is equivalent to a junior high school, and Madrasah Aliyah which is equivalent to a Senior High School. Students or usually be called as "santri" are also provided with life skills learning activities that aim to train students' skills and expertise. Drone technology is one of the latest technologies that need to be introduced to them, especially its contribution as a learning media in extracurricular activities at Pesantren Hidayatullah Yogyakarta.

1.1. Drone or Unmanned Aerial Vehicle (UAV)

Drone or UAV is an aircraft system without a crew or pilot inside it [7]. Drones are usually controlled by an operator remotely using a remote control, although now various types of drones can be operated autonomously based on coordinates points or programming codes. Currently, drones have been widely applied in various fields because drones are safer when operated and their costs are relatively cheaper [8]. Nowadays, drones are operated in real-time monitoring [9]. Real-time monitoring can be done using drones because most drones are currently equipped with a high-resolution camera so that real-time monitoring activities can be carried out properly. In addition, a drone has quite complex components, such as a brushless motor, propeller, battery, etc. [15]. Components of a drone can be seen in Figure 1.

![Figure 1. The Drone’s Components](image)

All of those drone components are very easy to buy or obtain in today's market with various types and advantages. Therefore, in this study, using a drone on the market was chosen, it’s and then modified to suit the study objectives. The drone was selected taking some consideration such as the price and technical capabilities of the drone that adapted to the study objectives. In terms of price, the drone should affordable prices, while in terms of technical capabilities, the drones must have an ability to record images and videos in good quality, because this drone was used for environmental monitoring and also as a learning media at Pesantren Hidayatullah. Referring to Stefano's study, drones with high recording resolution were the right choice to be used as a mapping or monitoring tool [13]. In addition, the technical capabilities of the drone should also be considered, such as the ease of control so that it can be operated by students easily.

These drone modifications were performed by adding a camera and a transmitter and receiver video. These additional devices were chosen so that the interface development can be carried out easily for this drone. The drone's interface development was carried out to suit the needs of this study's objectives. After the drone's interface development was completed, the next activities determined the coordinates
of several paths that will be passed by the drone. Examples of the coordinate points that have been taken at *Pesantren Hidayatullah* can be seen in Table 3. After all drone development was completed, the activity continues with the development of drone-oriented learning modules that had been developed to facilitate the delivery of material regarding drone operations.

1.2. Drone as a Learning Media

Learning media is needed by teachers as a tool in a learning process either in a classroom or in online learning. Learning media is a component of learning resources or physical devices that contain instructional materials for students that can stimulate students to learn [12]. Learning media currently has a function as a tool utilized by teachers to deliver material in their learning process [16] so that learning media has an important role in determining the effectiveness and efficiency of achieving learning objectives [17]. Therefore, it is not easy to choose suitable learning media to be applied in a learning process.

Some aspects need to be considered in choosing instructional media, such as suitability for learning objectives, capabilities and characteristics of the media, duration of media procurement, and the price of media itself [18]. Another aspect that needs to be considered in choosing learning media is the novelty of media technology. Learning media with the latest technology is proven to have a positive effect on students in terms of improving performance and their level of interactivity among students [19]. Therefore, learning media with the latest technology began to be implemented in a learning process as a learning media. Drones are one of the learning media that utilize modern technology.

Nowadays, robots are starting to be used in learning as media, including flying robots or drones, which are applied in mapping or monitoring lessons. Drones have many advantages, especially in terms of time flexibility, wider coverage area, and detailed work results [20]. In addition, drones can also be performed for programming learning media as an automatic delivery tool based on predetermined coordinate points [21].

Drones are also currently being developed as learning media by considering students' characteristics. Based on the study [22] students will not only be able to fly drones, but also students must be able to develop understanding deeply of drones and ethics in flying these drones. Furthermore, students not only learn skills but also they can create interdisciplinary knowledge, problem-solving abilities, and hands-on abilities by utilizing drones in the learning process.

1.3. Drone DJI FLY as a Learning Media

DJI FLY is an interface application with a simple and very intuitive design created by dji.com. This application is compatible with various types of drones such as Mavic Mini, Mavic Air 2, DJI Mini 2, DJI FPV, DJI Air 2S, and DJI Mini SE. This application can work on iOS and Android platforms with application version V 1.4.8 [23]. This application is also applied to fly and control drones, for example, the DJI Mini 2 drone. DJI FLY can order the drone to take pictures or videos with some techniques embedded in the system. The system is named the active track feature. This feature allows the drone to take video with some automatic movement. In addition, the DJI FLY can also control a drone's flight manually with pilot control. However, these video recordings with manual techniques may have lower quality than those with automatic video recordings. Therefore, the operation of the DJI FLY requires the ability of a pilot who is able to fly a drone so that good quality recordings are obtained as operated with automatic features. This condition is necessary for learner pilots, including "santri" at *Pesantren Hidayatullah*.

The drone learning module had been developed on how to manually fly a drone for "santri" and operate it. This drone learning module was developed based on the DJY FLY application which has been modified according to the characteristics of students. The drone learning module contains four materials, include basic drone’s theory, drone’s construction, drone’s operation, and drone’s maintenance. In addition, this study also developed two research instruments to determine the performance and feasibility of drones as learning media. The grids of these two instruments can be seen
in Table 2. Furthermore, to know the effectiveness of drones in learning, two drone comprehension instruments were developed that applied before and after learning or training activities.

| Table 1. The Performance and Feasibility Grids of Drone as a Learning Media |
|-----------------------------------|---------------------------------|
| **Aspects**                      | **Reviewed Studies**            |
| **Functionality**                |                                 |
| Navigation accuracy              | Material suitability            |
| Component’s functionality        | Material equipment              |
| **Usefulness**                   |                                 |
| Media benefits                   | Material collapse               |
| Media effectiveness              | Suitability with student characteristics |
| **Aspects**                      | **Reviewed Studies**            |
| **Functionality**                |                                 |
| Usefulness                       | Make material delivery easier   |
|                                 | Support learning process        |

2. Research Method

This study was carried out using the development approach developed by Alessi and Trollip [10] to produce drone as learning media and test its effectiveness. This study was conducted in three stages, including the planning, design and development stages as shown in Figure 1.

![Figure 2. The Drone’s Studies Stages](image)

As explained in [10], the steps of each stage can be described as follows: in the planning stage, researchers plan the need for drones that will be used as learning media by considering several aspects, such as determining the scope of drones as media, identifying students' characteristics, determining obstacles, determining development costs, making planning documents, making learning module, determining, and selecting materials, collecting data, and submitting user approvals. Designing stage was related to several activities such as collecting materials, designing drone performance tests, and drone feasibility tests in terms of functionality and the meaning of drones as learning media, its effectiveness. These steps were taken in this stage include developing ideas, compiling an analysis of drone test concepts, compiling a description of drone learning programs, preparing drone prototypes, creating flowcharts and storyboards, and submitting approval to users. The developing stage was assembling a drone that has been designed into a learning media product so that it was ready to be tested. This stage is carried out with several steps including preparing a drone prototype, determining coordinates, preparing learning modules, conducting training to students, conducting alpha tests, revising products, conducting beta tests, revising final products.

The results of designing drones as learning media are obtained through performance and feasibility tests carried out by experts who have some experience in the field of drone technology. Furthermore, the effectiveness test of drones as a learning medium was carried out through training for 30 students at the Madrasah Aliyah level at Pesantren Hidayatullah. The effectiveness test was conducted to determine
the level of students’ understanding before participating in the training (comprehension 1) and after completing the training (comprehension 2). The used instrument to determine the effectiveness of drones can be known through the coefficient results of Pearson's product-moment validity test of 0.482 to 0.885, while the coefficient of reliability test results with Cronbach's alpha obtained is 0.946. Data were analyzed using a descriptive approach which was presented through photo illustrations and graphics.

3. Research Results and Discussion

3.1. Development of Drone as Learning Media

As explained above, the DJI Mini 2 drone was chosen as a learning media in this study. The DJI Mini 2 drone was modified by adding a camera and a video transmitter and receiver to obtain monitoring recordings related to these study objectives. The changes to the specifications of the DJI Mini 2 Drone after modifications are made as shown in Table 2.

| No. | Specifications                  | Remark                      |
|-----|--------------------------------|-----------------------------|
| 1   | Weight                         | <249 g                      |
| 2   | Dimension                      | 245mm x 289mm x 56mm        |
| 3   | Sensor System                  | Downward system             |
| 4   | Distance range                 | 4 km                        |
| 5   | Maximum flight time            | 31 minutes                  |
| 6   | Camera                         | 12 MP                       |
| 7   | Video Resolution               | 4.0K, 2.7K                  |
| 8   | Battery Capacity               | 5200mAh                     |

Furthermore, the design of the Graphical User Interface or interface had done so that it can display objects that can convey information and represent the results for users. This interface is a system of interactive visual components for computer software. The design of this drone application interface is carried out to make it easier for students to know and control drones. Designing the drone application interface was applied by making storyboards to facilitate the further development process. The storyboard design of the drone interface can be seen in Figure 3.
After the storyboard was completed, the development of the drone application interface was carried out related to the storyboard design that had been made previously. Visualization of the drone application interface is shown in Figure 4.

![Figure 4. The Display of the Drone Application Interface at Pesantren Hidayatullah](image)

Establishing coordinate points was the drone utilization as a learning media for monitoring in Pesantren Hidayatullah environment. Coordinates setting is performed to determine routes or paths that will be passed by the drone. The results of defining the coordinate points at Pesantren Hidayatullah can be presented in Table 3.

| Waypoint | Names of Coordinate Point | Latitude     | Longitude       |
|----------|---------------------------|--------------|-----------------|
| H        | Home                      | -7.68086000530349 | 110.392019748688 |
| 1        | South-left point          | -7.68150626606614 | 110.39218939840794 |
| 2        | South-right point         | -7.681825575005529 | 110.39334811270237 |
| 3        | Lower-east point          | -7.681319863962482 | 110.39340376853943 |
| 4        | Center-east point         | -7.680899877461258 | 110.39342824369669 |
| 5        | Upper-east point          | -7.680740388807714 | 110.39310302585363 |
| 6        | North-right point         | -7.680390842632617 | 110.39322573691607 |
| 7        | North-center point        | -7.680345654132719 | 110.39271980524063 |
| 8        | North-left point          | -7.680219392122235 | 110.39239089936018 |

Based on these coordinate points are used to plan the drone flight path around Pesantren Hidayatullah complex as shown in Figure 5.
Finally, the final stage of developing drones as learning media is the development of drone learning module that are applied in extracurricular learning in Pesantren Hidayatullah. The results of designing drones as learning media are carried out through five main activities. Firstly, the activity of carrying out a needs analysis was carried out by reviewing several studies related to the application of drones in learning. Secondly, the activity identifies the scope by looking at what materials can be developed and collaborated with the application of drones as learning media. Third, activities to identify the characteristics of santri and extracurricular activities at Pesantren Hidayatullah can collaborate in applying a drone as learning media. Fourthly, making instruments for performance testing, feasibility tests, and learning media in the form of drones and training modules. Finally, the activity of testing the effectiveness of drones as a learning media through learning or training activities.

Based on the first, second, and third activity stages above, the development of a drone learning module had been compiled which contains five chapters covering the basic theory of the drone, drone components construction, drone operating, and drone maintenance. This drone learning module was delivered in theoretical and practical learning with a learning duration of 8 hours. In addition, the development of instruments on understanding this drone was also elaborated to determine the students' comprehension level toward drone learning before and after participating in this learning process. These drone comprehension instruments contain 20 questions respectively related to the material contained in the drone learning module. Furthermore, the instrument for drone media performance, the instrument for the feasibility of drone materials, and the effectiveness of a drone as learning media are also prepared with the completed grids of each of these instruments described in the further discussion section.

3.2. Performance of Drone as Learning Media
The media performance test was carried out to determine the performance quality of the modified drone. The drone media performance was tested by two experts who have expertise in this field. The tested aspects in this media performance test consist of two aspects which include the functionality aspect and the usability aspect. The functionality aspect consists of two reviews covering navigation accuracy and component functionality, while the usability aspect consists of two studies covering media meaning and media effectiveness as described in Table 1.

The results of the drone media performance test can be seen that the quality of this media is in the "Very Good" category (94.16%) that is relevant to the reference [11]. It means that the performance of this drone media can be utilized as a learning media. In addition, the result of this study is also in line with the study result referring to [15] that the result of the media performance test score of at least 82.10% can be stated to be included in the very feasible category.

![Figure 5. Drone Flight Path around Pesantren Hidayatullah Complex](image)
3.3. Feasibility of Drone as Learning Media

The feasibility test of the material is carried out by knowing the quality level of the drone material and the learning module separately. The feasibility of this drone material had been tested by two experts who have a comprehensive mastery of drone material. The aspects tested in the feasibility test of this material consist of two aspects which include material quality and material usefulness aspects as described in Table 1. The material quality aspect contains four studies which include material suitability, material equipment, material collapse, and suitability with student characteristics aspects. The usability aspect contains two studies which include making material delivery easier and supporting the learning process.

The results of the drone material feasibility test can be seen that the quality of this drone material is in the "Very Feasible" category (90.27%) that is relevant to the reference [11]. It means that the feasibility of this drone material can be applied to a learning process activity. This study result was reinforced by study results that refer to [14] which stated the result of the material feasibility test score of at least 82.50% can be stated to be included in the very feasible category.

3.4. Effectiveness of Drone as Learning Media

The beta test is carried out by measuring the effectiveness of a drone when it's applied in the learning process which was carried out through the Wilcoxon Signed Ranks Test before participating in the training and after completing the drone's training. The results of the beta test were shown that a drone as a learning media has a significant level of effectiveness (significant value of 0.000). This means that a drone as a learning media can increase a students' level of understanding in a learning process. This level of effectiveness was seen through the achievement of students' understanding of four main materials during drone training, including basic theory of the drone, drone components constructions, drone operating, and drone maintenance. Overall, the level of understanding of students before training (comprehension 1) and after training (comprehension 2) of the drone as a learning media is shown in Figure 6.

![Figure 6. The Overall Comprehension of Drone’s Knowledge and Skills](image)

The descriptions of the increment in the level of understanding achievement on the topics of the basic theory of drones, the drone components constructions, the drone operating, and the drone maintenance were reviewed in the dominant category when before and after completion of drone training. Each of those topics can explain that the student's comprehension of the basic theory of drones in the “very understand” category is increasing from 16.70% to 93.30%. The students' comprehension of the drone components construction in the “very understand” category is raised from 6.70% became 30.00%. The students' comprehension of the drone operating in the “very understand” category is a rise from 3.30% became 33.3%. The students' comprehension of the drone maintenance in the “understand” category is
ascended from 6.70% became 33.3%. The results of this study are in line with the results of research [22] which states that the use of media in learning has a positive effect on independent learning and more innovative thinking to students and is also relevant according to references [23] that stated utilizing learning media will enhance a learning process which in the end can improve quality and achieved learning outcomes.

4. Conclusion
The results of this study can be seen that drones can be developed and applied as a learning media for "santri" in Madrasah Aliyah level at Pesantren Hidayatullah. The results of the alpha test on drone media showed that the performance level of the drone was included in the "very feasible" category (94.16%) and also included in the "very good" category (90.27%) when viewed toward the media feasibility. Furthermore, the results of the beta test can determine the effectiveness of drones as a learning media that can significantly improve the quality of drone learning at Pesantren Hidayatullah. The results of this study can be concluded that drones as learning media can be applied in the learning process.

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