JPPIPA 10(12) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Predicting the Effect of Magnetic Acquisition Using CrowdMag Android App on Fundamental Magnetic Concepts Mastery in Basic Physics

Jufri[1*], Rizky Fatmalasari L[1], La Naston[1]

[1] Universitas Darussalam Ambon, Ambon, Indonesia.

Received: September 11, 2024
Revised: November 06, 2024
Accepted: December 25, 2024
Published: December 31, 2024

Corresponding Author:
Jufri
jufridarussalam@gmail.com

DOI: 10.29303/jppipa.v10i12.9131

Abstract: If the concept of the magnetic field is categorized as one of the physics concepts considered difficult by some students, then classroom instruction itself is not sufficient to explain it. This research reveals that integrating magnetic acquisition using the Android application CrowdMag in learning the concept of the magnetic field can be an effective solution. Testing 32 (on thirty-two) Faculty of Teacher Training and Education (FKIP) Universitas Darussalam Ambon students showed that magnetic acquisition using the Android application CrowdMag had a significant effect on the mastery of the magnetic field concept. This effect is not due to chance, as evidenced by a significant regression coefficient β and an F-calculated value greater than the F-table value, as well as a strong and linear correlation between the variables of magnetic acquisition and the mastery of the magnetic field concept. The resulting regression model (Y = 31.271 + 0.584X) can be used to predict the effect of magnetic acquisition using the Android application CrowdMag on the mastery of basic physics concepts of magnetic fields for students of FKIP Unidar Ambon.

Keywords: CrowdMag; Magnetic acquisition; Mastery of the magnetic field concept

Introduction

The concept of magnetic fields is categorized as one of the physics concepts that are still considered difficult by early-level students at Faculty of Teacher Training and Education (FKIP) Unidar Ambon. One of the reasons is because the concept is still theorized in class without being taught in practice. Practical application rare, and even when present, it is rare, and even when present, it is typically confined to standard experiments. As a result, it is less feasible to generalize these experiences to the functional use of magnetic field concept for exploring the student' surrounding environment. That means that classroom actions itself are not enough to explain the abstractness of the concept of magnetic fields. In addition, the difficulty in understanding the concept of magnetic fields makes the motivation to learn the concept less, which causes the level of mastery to be very low (Aswirna, 2018; Guido, 2018; Lestari et al., 2019) so that learning innovation is required. Thus, its concept can be applied in real situations, namely with magnetic acquisition. This is an implementation of a magnetic method based on measuring the contrast of rock magnetization from the induction of the earth's magnetic field (Jufri, 2012), which aims to produce a magnetic field contour map and modeling of the earth's subsurface rock structure. As a result, magnetic acquisition is basically done using a magnetometer, one of which is a PPM (Proton Precession Magnetometer) type magnetometer. From the function and purpose of magnetic acquisition, is it possible to integrate it into basic physics learning of the magnetic field concept? How to do it while the magnetometer is a type of tool that is rare in physics

How to Cite:
Jufri, L, R. F., & Naston, L. (2024). Predicting the Effect of Magnetic Acquisition Using CrowdMag Android App on Fundamental Magnetic Concepts Mastery in Basic Physics. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10677–10691. https://doi.org/10.29303/jppipa.v10i12.9131

laboratories. Then, do we have to rent or bring in a magnetometer just to master the basic physics of the concept of magnetic fields? Of course not. Indeed, in the real sense, magnetic acquisition requires a lot of resources and time, but with the development of current technology, an Android application can be used as a representation of a magnetometer, namely the crowdMag application. This application is used to measure and record magnetic field anomalies at the location where the smartphone is located (Crawmer, et al., 2019).

CrowdMag is an application developed by NOAA/CIRES to utilize magnetometers on smartphones (Saltus et al., 2020b). With the CrowdMag application, magnetic acquisition can be performed without the need to rent a magnetometer, which is often a barrier in physics experiments due to high costs and limited availability of equipment. This provides students with the opportunity to conduct experiments independently and directly experience how the concept of magnetic fields is applied in real-world situations. The use of this application also enables students to better understand the relationship between theory and practice, making physics learning more engaging and applicable.

Furthermore, this research is significant because many traditional methods for measuring magnetic fields still rely on expensive devices and the limited number of instruments available for research. With CrowdMag, not only can costs be reduced, but it also allows more students to actively engage in measuring and analyzing magnetic fields. According to previous studies, Earth's magnetic field measurements with CrowdMag can be modeled as contour maps using applications such as Surfer/Geosoft and MagPick. Additionally, this data can be used to describe the subsurface rock structures with the help of the Mag2DC application, opening new opportunities for more complex experiments and deeper understanding in geophysics.

What sets this research apart from previous studies is its focus on applying CrowdMag in the context of basic physics education, particularly in the concept of magnetic fields. Previous research generally evaluated this application from a technical perspective for magnetic data acquisition, while this study aims to explore the impact of using CrowdMag on students' understanding of basic physics content. Furthermore, this research also assesses how the data obtained can be used to create more comprehensive visual models, enriching students' understanding not only of the theoretical concepts but also of their practical applications.

By integrating this experimental approach into basic physics education, it is expected that students will gain a more comprehensive understanding of the concept of magnetic fields. They will realize that although the concept of magnetic fields is initially considered subjective and abstract, it can be objectively applied for broader purposes, including practical applications in geophysics and technology. This study aims to predict the effect of magnetic field acquisition using the CrowdMag Android application on the mastery of basic physics concepts related to magnetic fields among FKIP Unidar Ambon students. It is hoped that this research will contribute positively to the development of more efficient technology-based teaching methods that are relevant to the needs of modern education.

Method

This research is based on the use of the CrowdMag android application for magnetic field acquisition as an experiment integrated into basic physics learning on the concept of magnetic fields. According to Djamarah (2020), experimental approaches integrated into learning can enhance students' confidence in the theories being studied.

The research sample consisted of 32 (thirty-two) students from FKIP Unidar Ambon who were enrolled in the basic physics course. The magnetic field acquisition was conducted in the campus area of the University of Darussalam Ambon. The software used to create magnetic field contour maps and two-dimensional subsurface modeling based on the results of magnetic field acquisition with the CrowdMag android application included Excel, Surfer, MagPick, and Mag2dc. The research instruments used to predict the effect of magnetic field acquisition on the mastery of the concept of magnetic fields included a student activity observation sheet with eleven observation points, a questionnaire with fifteen closed-ended statements, and ten subjective questions. Creswell (2013) states that the predictive approach is used to determine how well one variable predicts the outcome of another variable.

The data obtained from the research instruments were analyzed using statistical correlation equations, product moment, and simple linear regression, as well as the Lilliefors equation to test the normal distribution of data for the magnetic field acquisition variable using the CrowdMag android application and the basic physics mastery variable for the concept of magnetic fields. This study employed three approaches: experimental, empirical, and predictive-correlative approaches. According to Bahar (2017), the empirical approach emphasizes that information must be obtained through direct observation in the real world. The results of these observations must be presented in the form of data, either quantitative or qualitative. In general, the research flow is illustrated in Figure 1.

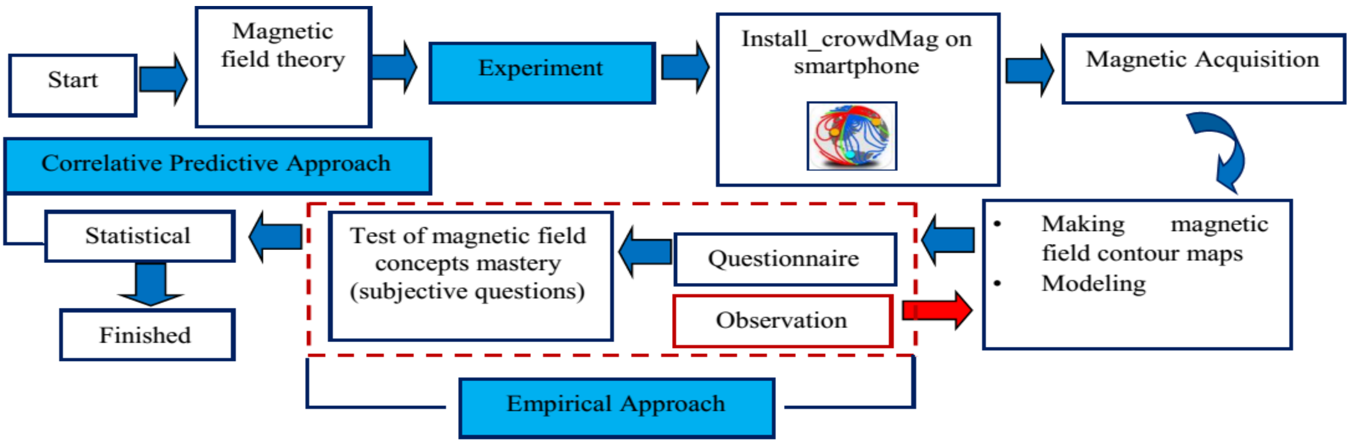


Figure 1. Research method flow

Result and Discussion

From the implementation of this research, FKIP Unidar Ambon students are able to conduct experiments through magnetic acquisition without renting a magnetometer. In addition, the students' experiences know how the concept of magnetic fields that are usually theorized in class could be applied in real situations. Students also learn to create contour maps and modeling of subsurface rock structures with surfer, mag2dc, and magpick software. The results of this study as a whole come from experimental and empirical approaches. Each approach has different data, but for the purposes of inferential statistical analysis, the data from the experimental approach was converted into quantitative data through the use of observation sheet instruments and questionnaires.

Experimental Approach

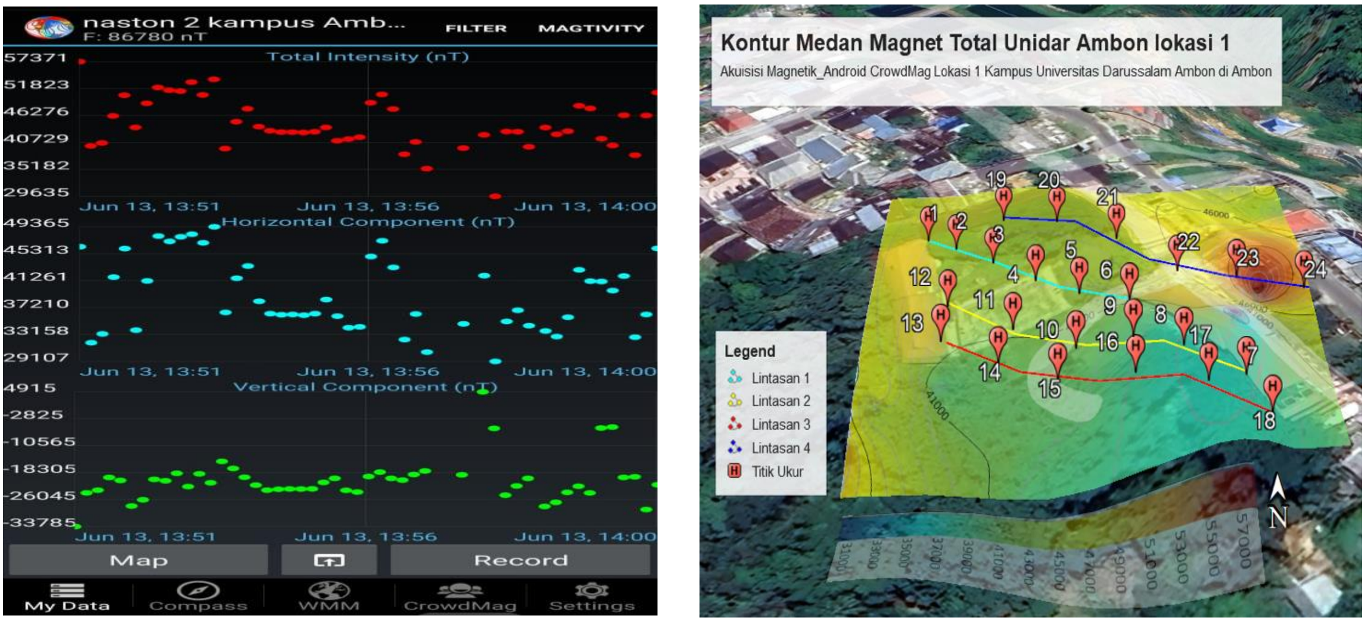
The experimental approach referred to in this study was student activities in magnetic acquisition using the crowdMag android application to the creation of magnetic field contour maps and two-dimensional modeling of subsurface structures. Initially, the concept of magnetic fields was presented classically to 32 (thirty-two) FKIP Unidar Ambon students who took basic physics courses as an introduction, then experiments were carried out through magnetic acquisition using the crowdMag android application, with the first procedure consisting of (a) Download then install the crowdMag application from Google Play or the Apple App Store, (b) Open the application and selecting "record" to start recording (magtivity), magtivity is a recording of magnetic activity using the cellphone's internal magnetometer to measure the magnetic field in an area, the recording results at each measuring point are recorded on the magnetic acquisition data sheet, (c) Magtivity activities is done by walking towards the measurement points, (d) students who act as acquirers must remove the metal attributes they are wearing to avoid noise, (e) after finishing recording process, press "Pause" then select "Filter" to remove noise, (f) save with the name magnetic acquisition, and (g) select "settings", then "export my data" to export the measurement results data and save it in CSV format.

(a) (b) (c)

Figure 2. Crowdmag android application display, (a) view on play store, (b) initial display for acquisition, (c) crowdmag obersvations display

The second procedure consists of (a) identify the measurement results recorded on the magnetic acquisition data sheet, (b) explain the technical aspects of processing magnetic acquisition data to students for making contour maps and two-dimensional modeling of subsurface rock structures, and at the end (c) Students process magnetic acquisition data to create contour maps and modeling subsurface rock structures. The appearance of the crowdMag android application is presented in Figure 2.

In order to facilitate observation of student activities in conducting magnetic acquisition experiments to modeling the results of magnesia, after the presentation of the magnetic field theory, students were divided into four groups. The magnetic acquisition process was carried out simultaneously and intended so that the magnetic data and coordinate points recorded during magnetic acquisition for all student groups could be the same, making the evaluation process of the contour results and two-dimensional models of the subsurface structure was not different. The following displays the results of magnetic acquisition on the crowdMag android application and the total magnetic anomaly contour map before being transformed which was overlaid on the google earth map of the magnetic acquisition measurement area shown in Figure 3.



(a) (b)

Figure 3. (a) Graph of magnetic acquisition results in the application, (b) Total magnetic field contour overlaid against for acquisition

The total magnetic field in the measured area was obtained through the use of the CrowdMag android application as a representation of the magnetometer. In general, the results obtained are still influenced by several factors, including changes in solar activity and the Earth's main magnetic field in the measuring area. The contour map in Figure 3.b, if made clearer, looks like Figure 4.

Analysis of Figure 4 presents a significant variation in the total magnetic field in the Unidar Ambon campus area in Wara Ambon. The maximum value of the measured total magnetic field is more than 57000 nT, while the minimum value is around 32000 nT. The crowdMag Android application (Figure 3.a) confirms these results with a more specific range of values, namely between 57371 nT to 29635 nT. The contour map also shows that most of the measurement area is dominated by total magnetic field values between 47000 nT to 43000 nT. It appears that the magnetic field value deviates from the earth's main magnetic field in the measurement area which is known to have a value of 41766.7 nT.

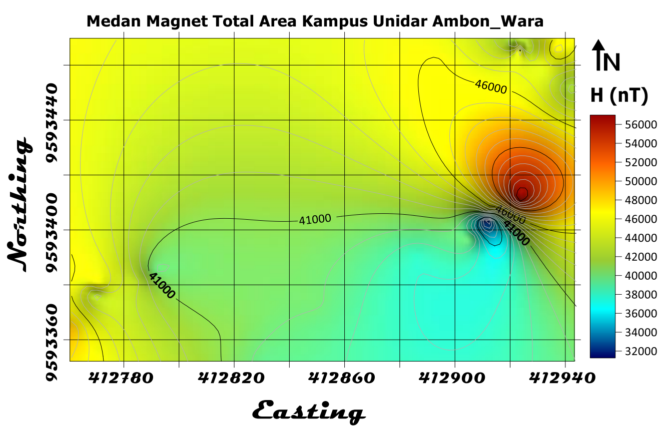


Figure 4. Total area magnetic field contour map of Unidar Ambon in Wara Ambon

According to Santoso (2002), magnetic field measurements on the earth's surface are the result of various variables. Yet, according to Green (1993), the influence of the earth's main magnetic field is only 99% and its variations are very slow and small, this means if the range of magnetic fields obtained from magnetic acquisition indicates that the measurement area has a magnetic anomaly. This magnetic anomaly is a phenomenon of changes in the magnetic field relative to the earth's main magnetic field as a result of the manifestation of magnetic remanence around the measurement area or below the surface. In this study, the magnetic anomaly contour map is divided into two, namely the total magnetic anomaly contour and the residual magnetic anomaly. In principle, the division of such magnetic anomalies is applied to magnetic acquisition using a real magnetometer, but as a form of learning and application of magnetic field theory in real conditions that can be directly experienced by FKIP Unidar Ambon students, magnetic acquisition using the crowdMag android application is designed in such a way that all processes are the same as using a real magnetometer

The total magnetic anomaly value was obtained from the acquisition time correction and the main magnetic field of the measurement area (IGRF data). The results are displayed in the form of a contour map as shown in Figure 5. From its figure, it is known that the total magnetic anomaly with a value of 4000 nT to the highest 18000 nT dominates the measurement area, except in the northeastern part which increases from 22000 nT to 36000 nT and part of the southwest from 20000 nT to 22000 nT. However, the total magnetic anomaly is still influenced by regional and local magnetic anomalies. Therefore, in its analysis, these two anomalies need to be separated through upward continuation transformation. In this study, the upward continuation process was carried out up to a height of 400 m using magPick software, so that regional anomalies (figure 6.b) and local anomalies (remainder) (figure 6.a) were obtained, but for two-dimensional modeling of the subsurface structure, local anomalies (remainder) were employed. After upward continuation, residual magnetic anomalies were obtained with magnetic field values of 18000 nT to the lowest - 14000 nT, positive and negative signs indicate variations in magnetic anomalies in the measurement area. The contour map of the total magnetic field anomaly, local magnetic anomalies and regional anomalies in the campus area Ambon Darussalam University in Wara Ambon as shown in Figure 5 and Figure 6.

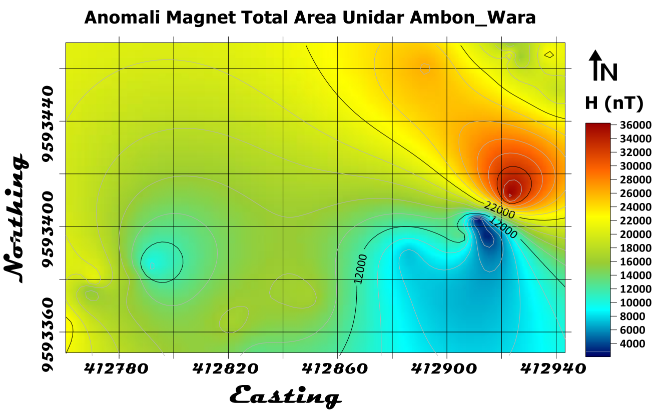
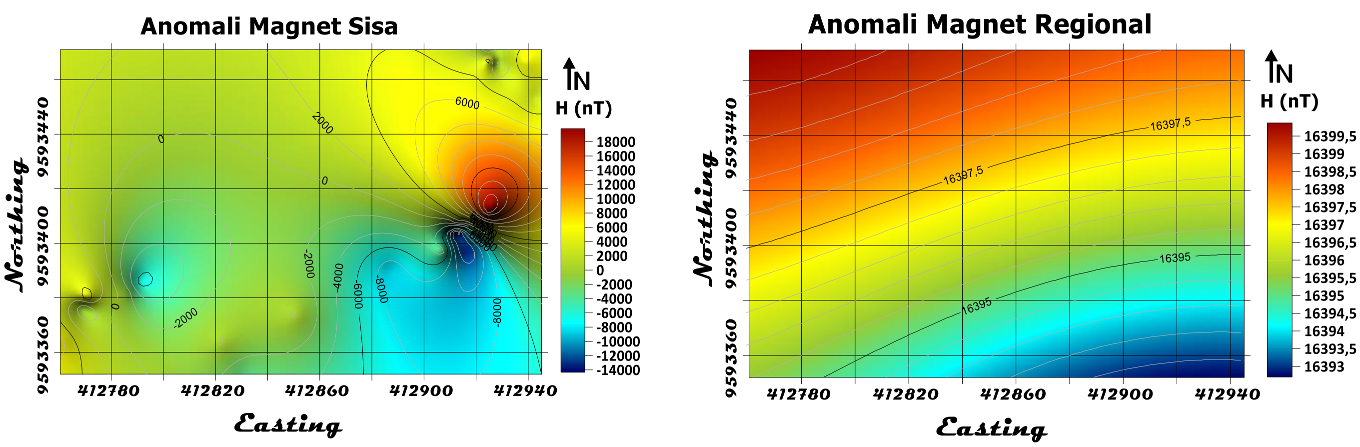


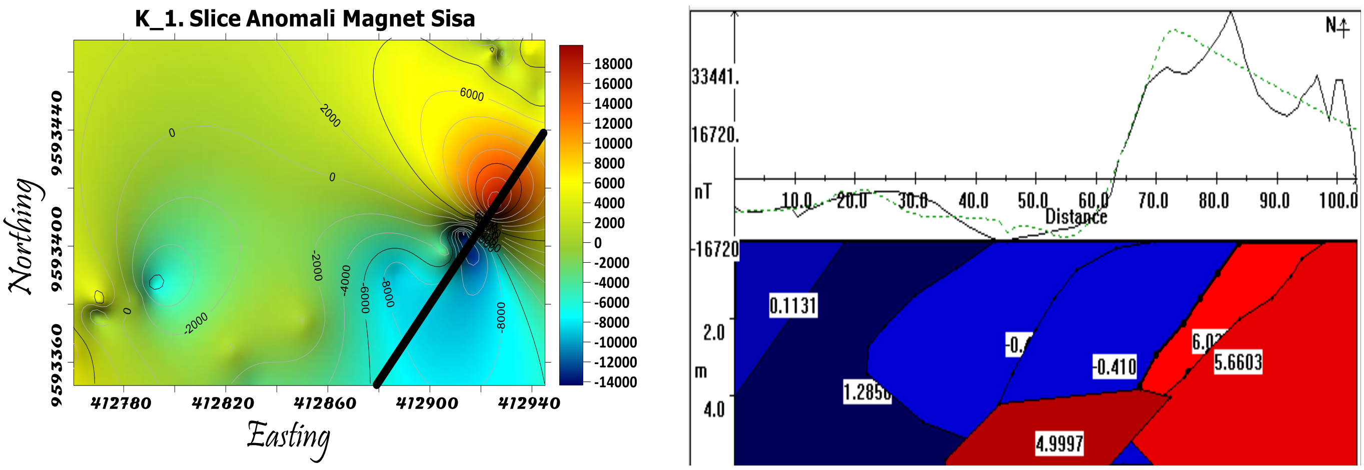
Figure 5. Total area magnetic field anomaly contour map of Unidar Ambon in Wara Ambo



(a) (b)

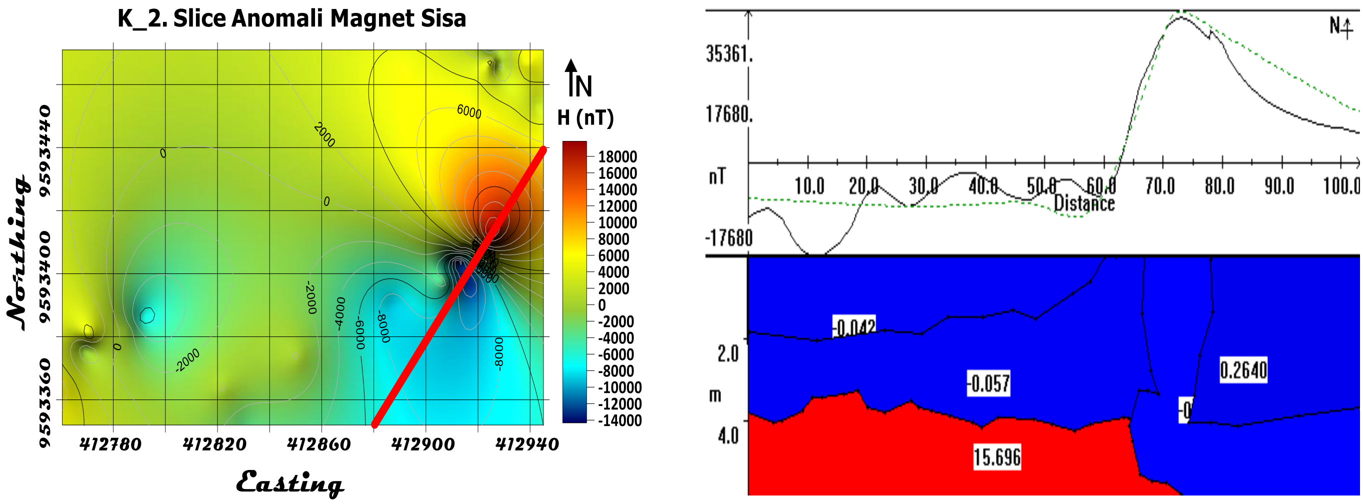
Figure 6. (a) Contour map of the remaining magnetic anomaly of the Ambon Darussalam University campus area in Ambon (wara), (b) Contour of the regional magnetic anomaly in Wara area

The contour map of the residual magnetic anomaly and the 2D model of the subsurface structure of the Unidar Ambon campus area in Wara as the result of student work from groups one to four are shown in Figures 7 to 10.



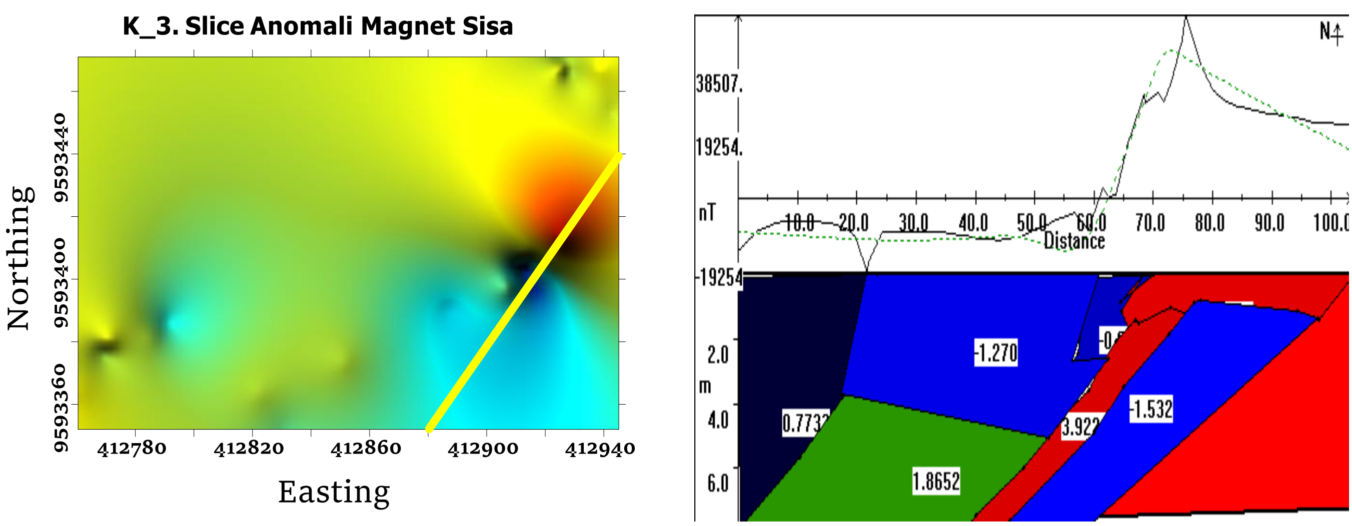
(a) (b)

Figure 7. Results of group 1's work (a) Contour map of the remaining magnetic anomaly of the Ambon Darussalam University area in Ambon (Wara), (b) The 2d model of the subsurface of the Ambon Darussalam University area in Ambon (Wara)



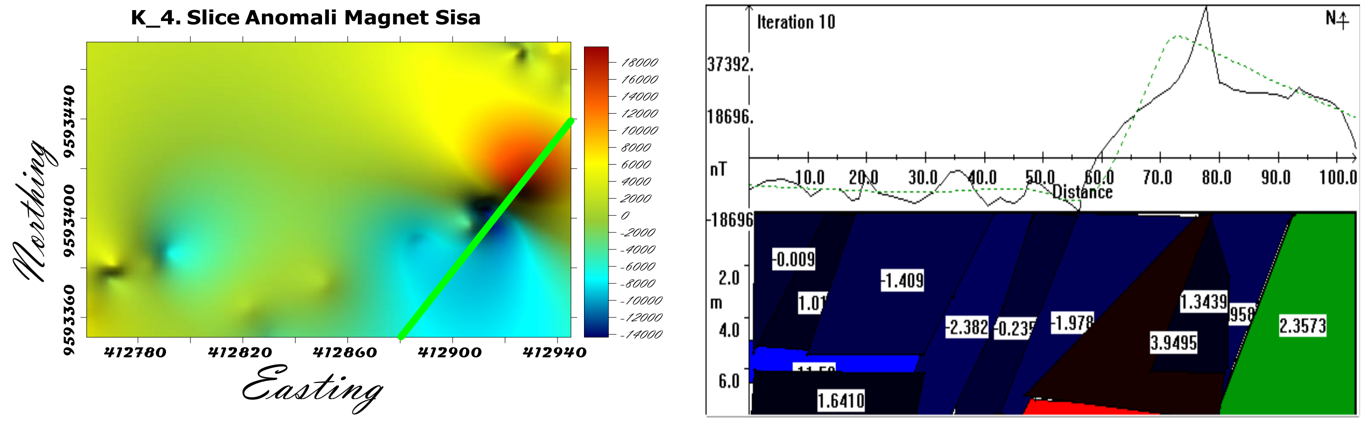
(a) (b)

Figure 8. Results of group 2's work (a) contour map of the remaining magnetic anomaly of the Ambon Darussalam University area in Ambon (Wara), (b) The 2d model of the subsurface of the Ambon Darussalam University area in Ambon (Wara)



(a) (b)

Figure 9. Results of group 3's work (a) contour map of the remaining magnetic anomaly of the Ambon Darussalam University area in Ambon (Wara), (b) The 2d model of the subsurface of the Ambon Darussalam University area in Ambon (Wara)



(a) (b)

Figure 10. Results of group 4's work (a) contour map of the remaining magnetic anomaly of the Ambon Darussalam University area in Ambon (Wara), (b) The 2d model of the subsurface of the Ambon Darussalam University area in Ambon (Wara)

The anomaly contour maps created by students, as seen in Figures 4 to 10 above, are sourced from the same data, namely data from magnetic field acquisition in the campus area of Ambon Darussalam University in Wara, Ambon, using the CrowdMag Android application.

The appearance of the residual magnetic field anomaly contour map made by each student group shows some differences in terms of design, but in general, the resulting contour map is in accordance with the measurement data. This can be seen from the placement of the coordinate positions and the distribution of the appropriate magnetic field anomaly values, with an anomaly value range between 40,000 nT to the lowest anomaly of -14,000 nT. Modeling with a cut from the southwest to the northeast has also been done well, although the modeling fit line has not been positioned perfectly. However, in general, students have been able to carry out the procedure for modeling two-dimensional structures below the earth's surface based on data from measurements of the earth's magnetic field.

Empirical Approach

Empirical approach means that the data analyzed in this study come from student activities, starting from magnetic acquisition with the crowdMag android application, contour map creation, 2-dimensional subsurface modeling, student responses to learning with magnetic acquisition and mastery of the concept of magnetic fields. In this approach, research data is classified into empirical data of X variable and empirical data of Y variable. Empirical data of X variable is obtained by converting student activities and responses to acquisition magnetic integrated in basic physics learning of the concept of magnetic fields, each using observation sheet instruments and questionnaire sheets, while empirical data for the Y variable were obtained through the use of subjective question sheet instruments to determine students' mastery of the concept of magnetic fields after learning with magnetic acquisition.

Table 1. Results of Observations on Student Activities

Observation Point	Frequency of Obtaining Rating Scales				
	0	1	2	3	4
Magnetic data retrieval using CrowdMag android application	-	-	-	2	30
Record the coordinate points on the data sheet according to the GPS data display.	-	-	-	4	28
Measuring magnetic fields using the CrowdMag application at precisely the specified measurement points	-	-	-	7	25
The magnetic acquisition data sheet is filled in according to the magnetic data read on the CrowdMag android application.	-	-	-	-	32
Process measurement data in Excel software according to the guide	-	1	1	16	14
Creating a magnetic field contour using Surfer software according to the guide	-	-	1	1	30
Performing an upward lift for magnetic data reduction	-	1	1	7	23
Perform subsurface structure modeling using Mag2dc software according to the guide	1	-	1	5	25
Interpret the model results by correlating the model results data with the rock susceptibility values contained in the guide.	-	1	-	4	27
Interpreting magnetic field contour maps	-	-	-	1	31
Each group member carries out tasks according to team agreement in magnetic data acquisition to modeling.	-	-	-	3	29

The results of observations of student activities related to the use of the CrowdMag Android application in an empirical approach indicate that the data analyzed in this study was derived from student activities. These activities included magnetic acquisition using the CrowdMag Android application, contour map creation, two-dimensional subsurface modeling, student responses to learning with magnetic acquisition, and mastery of the concept of magnetic fields. In this approach, the research data was classified into empirical data for variable X and empirical data for variable Y. Empirical data for variable X was obtained by converting student activities and responses to magnetic acquisition.

The contour maps of residual magnetic field anomalies created by each student group showed some differences in design. However, in general, the generated contour maps were consistent with the measurement data. This consistency was evident from the placement of coordinate positions and the distribution of magnetic field anomaly values, with anomaly ranges between 40,000 nT and the lowest anomaly of -14,000 nT. When the magnetic anomaly patterns were correlated with measurements conducted using the PPM G-856 magnetometer by Jufri et al. (2015) in the Tulehu area of Ambon Island, residual magnetic anomalies ranging from 2,000 nT to -1,200 nT were observed. Similarly, the research by Lewerisa (2019) in the Tulehu and Suli areas of Ambon Island using the magnetic inversion 3D model method yielded residual magnetic anomalies ranging from 810.67 nT to -885.52 nT. These findings indicate that measurements using the CrowdMag Android application still align with geophysical data from the surveyed area.

Thus, these results support the opinion of Saltus et al. (2020) that the CrowdMag Android application can be used to model subsurface geological conditions, although it is not as precise as dedicated magnetometer instruments. Modeling with a cut from the southwest to the northeast had also been done well, although the modeling fit line had not been positioned perfectly. However, in general, students have been able to carry out the procedure for modeling two-dimensional structures below the earth's surface based on data from measurements of the earth's magnetic field acquisition. In magnetic field learning indicates that of the 32 students who were the research sample, around 84.09% or 27 students were able to perform magnetic acquisition very appropriately, as read in Table 1. Of the eleven observation points, the highest and most scale obtained by students was scale 4, namely very appropriately, there was no improvement, this means that most students already have the ability to take magnetic data, record coordinate points, and measure magnetic fields exactly at the specified measurement points, they also succeeded in filling in the magnetic acquisition data sheet according to the data read in the application. Data processing with excel software and making magnetic field contours using surfer software was also carried out well, although there were slight variations in the appearance, but most students were able to perform magnetic data reduction and subsurface structure modeling with magpick and mag2dc software interpretation.

The results of the magnetic field model and contour map were also done very well by almost all students. Overall, all students succeeded in carrying out their tasks according to the team's agreement, showing the effectiveness and efficiency of using supporting applications and software in learning magnetic fields. These observation data are consistent with several examples of contour map displays and 2-dimensional modeling results of subsurface structures made by student groups in Figures 2 to 5.

Frequency of responses from 32 (thirty-two) FKIP Unidar Ambon students as the samples or respondents on the magnetic acquisition process using the crowdMag android application in basic physics learning the concept of magnetic fields is presented in Table 2.

From table 2, it is known that the majority of students who were respondents agreed that magnetic acquisition using the crowdMag android application helped them understand the concept of magnetic fields better, made learning the physics concept of magnetic fields more interactive and interesting, and improved their ability in experiments. They were also interested in studying magnetic fields further after using the application. Data from the crowdMag android application Frequency of responses from 32 FKIP Universitas Darussalam Ambon students as the samples or respondents. The results of the magnetic field model and contour map were also done very well by almost all students.

Overall, all students successfully completed their tasks in accordance with the team’s agreement, demonstrating the effectiveness and efficient of utilizing supplementary application and software in learning about magnetic fields. The observational data align with examples of contour map displays and two-dimensional models of subsurface structures created by student groups, as shown in Figures 2 to 5. These tools were considered beneficial for enhancing understanding of magnetic field phenomena and added value to the learning process. Additionally, the majority of respondents, 27 students, disagreed that the application was too challenging to use or disruptive to the learning process. On the contrary, they rejected the notion that irrelevant or confusing applications. The crowdMag application was well received by the majority of respondents, who felt that the use of magnetic acquisition crowdMag android app helps understanding, increases interest, and makes learning magnetic fields more interactive and fun.

The form of concept mastery according to Silaban (2014) in Haerunnisa et al. (2021) means an effort that must be made by students to store and repeat a number of pieces of information from certain subject matter that can be used to solve problems, analyze, and interpret certain events, then emphasized by Nisrina et al. (2017) in Haerunnisa et al. (2021) that students with good conceptual mastery will be faster in carrying out tasks related to procedural knowledge and are able to complete all forms of tasks given perfectly.

Table 2. Student Responses to the Magnetic Field Learning Process Using the Magnetic Acquisition Approach_Application Crowdmag in Basic Physics Learning Magnetic Field Concept

Statement	Frequency Selection				
	5	4	3	2	1
Magnetic acquisition using CrowdMag android application in learning helps me understand the concept of magnetic fields better	27	5	-	-	-
I am interested in studying magnetic fields after performing magnetic acquisition using the CrowdMag application.	6	26	-	-	-
Magnetic acquisition using the CrowdMag application in magnetic field learning provides an interactive and engaging learning experience.	29	3	-	-	-
The data obtained from the CrowdMag application makes it easier for me to understand the magnetic field phenomenon.	8	24	-	-	-
The use of magnetic acquisition with the CrowdMag application during learning improved my ability to conduct experiments on magnetic fields.	5	27	-	-	-
Magnetic acquisition using the CrowdMag application makes learning magnetic fields more fun and less boring.	29	3	-	-	-
Acquisition with the CrowdMag application is too difficult to do and interferes with the learning process.	-	-	-	24	8
The concept of magnetic fields becomes easier to understand with the magnetic acquisition approach.	6	26	-	-	-
With magnetic acquisition using the crowdMag android application, I can find out how changes in the magnetic field in a certain area affect something below the earth's surface.	5	27	-	-	-
Acquisition using the CrowdMag android application and the process of modeling the subsurface structure did not add any value to my understanding of magnetic fields.	-	-	-	1	31
Learning magnetic fields with a magnetic acquisition approach is not relevant to the magnetic field theory that is taught.	-	-	-	1	31
The activity of modeling 2D subsurface structures from the results of the acquisition of the earth's magnetic field using the crowdMag android application made me even more interested in studying the concept of magnetic fields.	3	29	-	-	-
Data obtained from magnetic acquisition results with the CrowdMag application is often inaccurate and confusing.	-	-	-	27	5
I am pleased with the appearance of the magnetic field contours resulting from the magnetic acquisition.	6	26	-	-	-
I am not interested in studying magnetic fields after performing magnetic acquisition using the CrowdMag application.	-	-	-	19	13

In this study, there are several characteristics that serve as a reference that FKIP Unidar Ambon students who take basic physics courses are stated to have mastered the concept of magnetic fields. After learning with magnetic acquisition using the crowdMag android application, namely if they can meet the following learning achievement targets, including (1) analyze the attraction and repulsion between magnetic poles based on their distances in question item number 4, (2) be able to use a mathematical approach to solve magnetic field problems in subjective question number 10, (3) be able to analyze experimental data or magnetic acquisition and make relevant conclusions based on magnetic field theory according to questions 1, 2, and 3, and (4) be able to measure magnetic fields using the crowdMag android application in certain areas to detect magnetic anomalies and display the results in the form of contour maps and subsurface models in subjective questions 5 to 9. Indeed, in order to achieve the target of learning basic physics, especially the concept of magnetic fields, it is not just about fulfilling what has been mentioned above, but in this study, the target of mastering the concept of magnetic fields is limited to these things. Data on mastery of the concept of magnetic fields was obtained by applying a subjective test instrument consisting of 10 questions to sample students. The questions were arranged based on the 4 learning achievement targets above. The instrument was provided to students at the end of the learning or after the magnetic acquisition process with the android application crodwmag. The following is a table of the final value obtained by students for each learning achievement target.

Table 3 shows that students have good abilities in analyzing the attraction and repulsion forces between magnetic poles with the highest score of 5 achieved by 32 students.

Table 3. Scores Achieved for Each Target Achievement of Mastery of the Magnetic Field Concept

Target Achievement	Item Number	Total score	Value obtained		Frequency of Values obtained	
			Highest	Lowest	Highest	Lowest
Analyzing the attraction and repulsion between magnetic poles based on their distance	4	5	5	-	32	-
Able to use mathematical approaches to solve magnetic field problems	10	15	15	7	27	5
Able to analyze experimental data or magnetic acquisition results and make relevant conclusions based on magnetic field theory.	1	10	10	7	28	4
	2	10	10	5	29	3
	3	10	10	9	29	3
Able to perform magnetic field measurements using the crowdMag android application in certain areas to detect magnetic anomalies and display the results in the form of contour maps and subsurface models.	5	5	5	-	32	-
	6	5	5	-	32	-
	7	20	15	10	29	3
	8	10	10	9	28	4
	9	10	10	7	29	3

The ability to use a mathematical approach to solve magnetic field problems is also high, although there are variations in values between 15 and 7. In terms of analyzing data from acquisition results magnetic, most students get a perfect score of 10, with some students getting lower scores, while the ability to measure magnetic fields using the CrowdMag Android application shows varying results, with the highest score being 15. But overall, the mastery of the magnetic field concept by students after learning through the magnetic acquisition approach using the crowdMag android application has met the learning achievement targets in this study. The data on students' mastery of the magnetic field concept, which have been categorized according to Unidar Ambon's academic guidelines are shown in table 4.

Table 4. Category of Mastery Level of Magnetic Field Concept of FKIP Unidar Ambon Students

Mastery Level	Category	Frequency	Presentation	Information
80-100	Excellent	29	90.62%	Passed
70-79	Good	3	9.38%	Passed
60-69	Enough	-	-	Passed
50-59	Not enough	-	-	Passed
40-49	Very less	-	-	Conditional Pass
30-39	Fail	-	-	Not pass
Amount		32	100%	Passed

Table 4 shows that of the 32 (thirty-two) students evaluated, 29 (twenty-nine) students (90.62%) had very good mastery of the concept of magnetic fields, with one student obtaining a score of 95 and 28 other students obtaining very good scores varying from 90 to 80. Furthermore, three students are in the good category with a score of 72 to 79. This means that all students who were evaluated were declared to have passed, with the majority being at a very good level of mastery of the concept of magnetic fields. The results obtained confirm that the media integrated into learning can provide convenience in understanding an abstract concept of magnetic fields, this is in accordance with the opinion of Dewi (2019) that learning using media can be a solution to explain the abstract concept of magnetic fields

Correlative Predictive Approach

Correlative prediction is a statistical approach based on correlation and regression analysis. According to Achmad et al. (2021), correlation analysis functions to determine the direction and strength of the correlation between two variables, while regression is used to predict how much the value of the dependent variable will change if the independent variable changes, which is reinforced by Agus (2004), that one of the requirements for being able to make predictions on dependent variables is the existence of a significant correlation between the independent and dependent variables. Thus, the implementation of the correlative predictive approach requires correlation analysis as a regression function.

In this study, the data for X variable (magnetic acquisition using the crowdMag android application) and Y (mastery of basic physics of magnetic field concepts) were analyzed for their connectivity and influence using statistical equations of product moment correlation and simple linear regression. This aims to predict the influence of magnetic acquisition using the crowdMag android application on the mastery of basic physics of magnetic field concepts of FKIP Unidar Ambon students. As parametric statistics, the product moment correlation equation and simple linear regression required that the analyzed data must meet the normality test.

The assumption of normality is included in educational research as it is closely related to the nature of the research subject, namely regarding the ability of a person in his group, and the normality test used in this study is the Lilliefors test. According to Achmad et al. (2021), the Lilliefors test is a statistical test to test the normality of data based on single data or data that has not been grouped for both large and small amounts of data. In the Lilliefors test, the data distribution is said to be normal if Lcount < Ltable both at the 95% and 99% significance levels. The following are the results of the Lilliefors test on the normality of the data for X and Y variables in this study.

Table 5. Results of the Normality Test of the Data for X and Y Variables

Variables	L_{count}	L_{table} N = 32, α = 0.01 and α = 0.05 (100% - 1% = 99%)	(100% - 5% = 95%)
X Variable	0.090	0.179	0.154
Y Variable	0.127		

The results of the Lilliefors test reveal the distribution of magnetic acquisition variable data for the crowdMag Android application (X) and the data patience of the basic physics mastery variable of the magnetic field concept of FKIP Unidar Ambon students (Y) each with a total of 32 data have calculated results (L count) of 0.090 and 0.127, which are smaller than L table 0.179 and 0.154 at a significance level of 95% and 99%. Thus, the data of X and Y variables are normally distributed, meaning that the distribution of the data has met the requirements for the use of product moment correlation analysis and simple linear regression.

Next, the data for X and Y variables were analyzed for their correlation using the product moment correlation equation, with a degree of freedom of 30 and the selected significance levels were 95% and 99%. A summary of the results of the product moment correlation analysis and the coefficient of determination in this study is presented in Table 6.

Table 6. The r_{count} Value (r_{xy}) and r_{table} Magnetic Acquisition Variable Android Application Crowdmag on the Variable of Mastery of Basic Physics Concept of Magnetic Field of FKIP Unidar Ambon Students

Degrees of freedom (32-2)	r_{count} value (r_{xy})	Coefficient of determination	Mark r_{table} 100% - 5% = 95%	100% - 1% = 99%
30	0.764	58.39 %	0.349	0.449

Based on table 6, it is known that the rcount value (rxy) is 0.764, which is greater than 0.349 and 0.449, which are the rtable values at the 95% and 99% significance levels, which means that there is a significant correlation or strong between the magnetic acquisition variables using the crowdMag android application on the basic physics mastery variables of the magnetic field concept of FKIP Unidar Ambon students. As according to Sudijono (2012), the magnitude of the r product moment (rxy) with a value of 0.70 to 0.90 is interpreted between X and Y variables has a strong correlation, while from the coefficient of determination shows that the mastery of the concept of magnetic fields of FKIP Unidar Ambon students who were the research sample was influenced by basic physics learning integrated with magnetic acquisition using the crowdMag android application by 58.39%. This is in accordance with the opinion by Supranto (2003), if there is a correlation and influence.

In this study, the results of three sources of variation calculation of simple linear regression, the sum of squares of inequalities, and the sum of squares of errors combined in the analysis of variance table on the significance of regression coefficients and linearity of regression equations, as well as the regression coefficient values α and β for simple linear regression equations are shown in table 7 and table 8.

Based on Table 7, ANOVA on the regression coefficient and linearity of the regression equation in this study is significant at the 95% and 99% confidence levels, indicated by the F-count value for the average comparison of b/a regression and residual regression of 42,097, which is greater than the F-table value of 4.17 and 7.56.

It indicates that the magnetic acquisition process using the crowdMag android application in basic physics learning significantly affects the variable mastery of the concept of magnetic field in this regression model with coefficients α and β as shown in table 8.

Table 7. Anova on Significance of Regression Coefficient and Linearity of Regression Equation

Source of Variation	Dk	SS	MS	F_{count}	F_{table} 95%	F_{table} 99%
Total	32	226943.615	-			
A regression	1	226296.281	226296.281	42.097	4.17	7.56
b/a regression	1	377,616	377,616			
Remainder	30	269,718	8,970			
Inequality	11	55,018	5.001	0.443	2.34	3.36
Error	19	214,083	11,267			

The regression coefficient that most determines the prediction value is the regression coefficient β (Agus, 2004). Therefore, the regression coefficient test in this study is focused on testing the regression coefficient β, with the results as shown in table 8. From the test results, the t-count value for the regression coefficient β was obtained at 6.488, which is greater than the t-table value at the 95% (2.042) and 99% (2.750) significance levels.

This shows that the regression coefficient β with a value of 0.584 to predict mastery of the magnetic field concept based on crowdMag magnetic acquisition is not caused by chance alone. In addition, the results of the linearity test in Table 7 indicate that the f-count value for the comparison of the average number of inequalities and the average number of errors of 0.443 is smaller than the f-table value at the 95% (2.34) and 99% (3.36) confidence levels. This shows that the correlation between X and Y variables is linear and strong. Thus, the simple linear regression equation model Y = 31.271 + 0.584X, which is derived based on the regression coefficients α and β, can be used to predict the effect of magnetic acquisition using the crowdMag android application on the mastery of basic physics concepts of magnetic fields of FKIP UniDar Ambon. This model is proven to be valid and reliable because the regression coefficient β is significant and the correlation between X and Y variables is linear and strong.

Table 8. Regression Value Coefficients of α and β

Regression coefficient	Value	Standard deviation, standard error of regression coefficient	t_{count}	t_{table} 95%	t_{table} 99%
α	31.271	-	-	-	-
β	0.584	0.090	6.488	2.042	2.750

There is an influence of magnetic acquisition using the crowdMag android application in basic physics learning. The concept of magnetic fields fulfills the function of the constructivism theory of Jean Piaget and Lev Vygotsky, where Piaget emphasized that learning is an active process in which students develop their knowledge through interaction with the environment. The results of this study also strengthen the research of Kozhevnikov et al. (2013) on the use of media in learning that can improve conceptual understanding.

Limitations with Previous Research

It has been explained previously that this research is a field-based experimental research/survey through magnetic acquisition using the crowdMag android application integrated into the learning of physics concepts of magnetic fields. From the implementation of this research, FKIP Unidar Ambon students can conduct experiments through magnetic acquisition without renting a magnetometer. In addition, students experience for themselves how the concept of magnetic fields that are usually theorized in class is applied in real situations. Moreover, the sudents also learn how to create contour maps and modeling of subsurface rock structures with excel, surfer, magpick and mag2dc software based on magnetic acquisition results, so that problems related to the lack of experiments and supporting tools for learning basic physics concepts of magnetic fields can be solved through learning innovations by utilizing android technology.

In essence, there has been previous research with the integration of Android technology in learning the concept of magnetic fields, as well as research using the CrowdMag Android application to measure the Earth's magnetic field, but these studies have different limitations from this study, as shown in Table 9.

Table 9. Previous Research on Integration of Android Technology in Physics Learning Magnetic Field Concept and Crowdmag Application

Researcher	Title	Limitations of this Research
Rizti Yovan & Kholiq (2021)	Development of Augmented Reality Media to Train High School Students ' Abstract Thinking Skills on Magnetic Field Material	Limited to media validity, and not simulated.
Fadli (2021)	Development of Android-Based Learning Media Using App Inventor to Enhance Students' Science Process Skills (SPS) on Magnetic Field Material	Not used as a representation of magnetic field experiments especially in magnetic field surveys or magnetic acquisition.
Crawmer et al. (2019)	Using CrowdMag to Catalog Magnetic Anomalies from Urban Infrastructure and Geological Features	These four studies (3-6) are only based on the use of the CrowdMag Android application to measure magnetic fields or more on the implementation of Android technology, but have not been applied in basic physics learning of the concept of magnetic fields for both students and university students.
Saltus et al. (2020)	CrowdMag for personal interaction with Arctic magnetic variation	
Wang et al. (2024)	CrowdMag Map: Crowdsourcing based Magnetic Map Construction for shopping malls	
Saltus & Nair (2017)	The CrowdMag App - turning your smartphone into a traveling magnetic observatory	
Odenwald (2022)	Can Smartphones Detect Geomagnetic Storms?	This research focuses more on the use of smartphones as detectors of the earth's magnetic field, but is not applied as a simulation medium for students or university students in learning about magnetic fields.
Researcher	Title	Limitations to this Research
Uspensky (2020)	Utilizing Smartphone Sensors to Monitor Geomagnetic Conditions in a Power System Region	Limited to observations of geomagnetic phenomena only
Skorokhodov et al. (2013)	Considering the Influence of Geomagnetic Storms When Designing Various Systems	Oriented towards the calculation of magnetic storm phenomena
Hendratno (2021)	The Use of a Shaking Needle Media in Magnetic Field Material to Enhance Students' Conceptual Understanding	This research is based on the media of a swinging needle in learning about magnetic field compasses and in the experiment. It can show magnetic force lines and coil magnetic poles, also improve students' understanding of the concept of magnetic fields. However, this research is not Android-based and is not applied in modeling magnetic field contours by students, let alone for students.
Soeharto (2022)	The Use of "Micopascien" Learning Media to Improve Understanding of the Magnetism Concept	Class-based only
Jufri et al. (2015)	Prediction of the Impact of Simplifying Physics Formulas on Physics Concept Mastery (A Study on Physics Students at FKIP Darussalam University Ambon on the Concept of Electromagnetic Waves)	Limited to the study of proof and derivation of formulas

Conclusion

The results of this study indicate that there is a significant effect of magnetic acquisition using the crowdMag android application on the mastery of the magnetic field concept of FKIP Unidar Ambon students, who take basic physics courses. Moreover, this effect is not due to coincidence, as evidenced by the significant β regression coefficient and the correlation between the magnetic acquisition variable and the mastery of the magnetic field concept which is linear and strong. This finding indicates that the integration of magnetic acquisition using the crowdMag android application in basic physics learning can be utilized to predict the ability to master the magnetic field concept of FKIP Unidar Ambon students. The results of this study emphasize the importance of innovation in learning methods, especially in utilizing digital technology to support and enrich the education process. The crowdMag android application can function as an effective tool for teaching basic physics of complex magnetic field concepts in a more interesting and easy-to-understand way for students. Thus, the integration of this technology can improve the quality of physics learning at Universitas Darussalam Ambon and support students' mastery of the magnetic field concept better.

Acknowledgments

Thanks are conveyed to the Ministry of Education, Culture, Research and Technology, Directorate General of Higher Education, Research and Technology, Indonesia for the research funding provided through No. 0667/E5/AL.04/2024, to Darussalam University of Ambon under the auspices of the

Darussalam Maluku Foundation for the research opportunity provided, Physics Education Study Program, FKIP, Darussalam University of Ambon, the entire research team, and to the students involved in the research.

Author Contributions

In this study, the main author Jufri is responsible for the research design, magnetic data processing, including writing the initial draft of the research manuscript. Meanwhile, Risky Fatmalasari L is responsible for the design of the research instrument, and processing of student learning outcome data, while La Naston is responsible for the magnetic acquisition process using the CrowdMag Android application.

Funding

This research is funded by the Ministry of Education, Culture, Research and Technology Directorate General of Higher Education Research and Technology, Indonesia, through grant No. 0667/E5/AL.04/2024.

Conflicts of Interest

The authors declare no conflict of interest in the publication of this article. The funders had no role in the study design, data collection, analysis, or interpretation of the data. The funders were also not involved in the writing of the manuscript or in the decision to publish the results of this study. All decisions taken are entirely the responsibility of the authors, without any intervention or influence from external parties related to this research.

References

Achmad, N., Kuswati, & Imronudin. (2021). *Teori dan Praktik Statistik* (Issue June). Jasmine

Agus, I. (2004). *Statistik Konsep Dasar Dan Aplikasi.* Jakarta: Kencana Prenada Media.

Aswirna, P. (2018). Application Of Treatment Trait Interaction To Improve Learning Of Chemistry. *SHS Web of Conferences*, *42*, 00114. https://doi.org/10.1051/shsconf/20184200114

Bahar, A. (2017). Membuat Kuis Interaktif Kelas dengan Quizizz. Retrieved from https://www.ahzaa.net/2017/08/membuat-kuis-interaktif-kelas-dengan.html#gsc.tab=0

Crawmer, P., Saltus, R., & Nair, M. (2019). Using CrowdMag to Catalog Magnetic Anomalies from Urban Infrastructure and Geological Features. In *AGU Fall Meeting Abstracts* (Vol. 2019, pp. IN51E-0686). Retrieved from https://ui.adsabs.harvard.edu/abs/2019AGUFM IN51E0686C/abstract

Dewi, F. S. (2019). Pengembangan Media Pembelajaran Medan Magnet dan Induksi Elektromagnetik Berbasis Computer Assisted Instruction (Cai) Di Universitas Negeri Surabaya. *Jurnal Pendidikan Teknik Elektro*, *8*(1), 133–137. https://doi.org/10.26740/jpte.v8n1.p%25p

Djamarah, S. B. (2020). *Strategi Belajar Mengajar*. Jakarta: Rineka Cipta.

Fadli, R. C. (2021). *Pengembangan Media Pembelajaran Berbasis Android dengan App Inventor untuk Meningkatkan Keterampilan Proses Sains Peserta Didik pada Materi Medan Magnet*. UIN Syarif Hidayatullah Jakarta.

Green, R. (1993). Applied geophysics. *Journal of Applied Geophysics*, *30*(4), 322–323. https://doi.org/10.1016/0926-9851(93)90043-x

Guido, R. M. D. (2018). Attitude and Motivation towards Learning Physics. *International Journal of Engineering Research & Technology (IJERT)*. https://doi.org/10.48550/arXiv.1805.02293

Haerunnisa, Makhrus, M., & Hikmawati. (2021). Pengembangan Perangkat Pembelajaran Berbasis Pendekatan Konflik Kognitif Berbantuan Video Pembelajaran Untuk. *Jurnal Ilmiah Profesi Pendidikan*, *6*(4), 739–743. https://doi.org/0.29303/jipp.v6i4.341

Hendratno, B. (2021). Pemanfaatan Media Shaking Needle pada Materi Medan Magnet untuk Meningkatkan Pemahaman Konseptual Siswa. *Educator : Jurnal Inovasi Tenaga Pendidik Dan Kependidikan*, *1*(22), 159–167. https://doi.org/10.51878/educator.v1i2.727

Jufri, J. (2012). Prediction of the Impact of Simplifying Physics Formulas on Physics Concept Mastery (A Study on Physics Students at FKIP Universitas Darussalam Ambon on the Concept of Electromagnetic Waves). *BIMAFIKA: Jurnal MIPA, Kependidikan Dan Terapan*, *4*(1), 110–115.

Jufri, J., Sunaryo, S., & Susilo, A. (2015). Pendugaan Formasi Batuan Reservoir dan Batuan Penudung di Area Manifestasi Panasbumi Tulehu Salahutu – Pulau Ambon Berdasarkan Survei Magnetik. *Natural-B*, *3*(2), 158–165. https://doi.org/10.21776/ub.natural-b.2015.003.02.9

Lestari, F., Saryantono, B., Syazali, M., Saregar, A., Madiyo, Jauhariyah, D., & Umam, R. (2019). Cooperative learning application with the method of network tree concept map: Based on Japanese learning system approach. *Journal for the Education of Gifted Young Scientists*, *7*(1), 15–32. https://doi.org/10.17478/jegys.471466

Nisrina, N., Gunawan, G., & Harjono, A. (2017). Pembelajaran Kooperatif dengan Media Virtual untuk Peningkatan Penguasaan Konsep Fluida Statis Siswa. *Jurnal Pendidikan Fisika Dan Teknologi*, *2*(2), 66–72. https://doi.org/10.29303/jpft.v2i2.291

Odenwald, S. F. (2022). Can Smartphones Detect Geomagnetic Storms? *Space Weather*, *20*(3). https://doi.org/10.1029/2020SW002669

Rizti Yovan, R. A., & Kholiq, A. (2021). Pengembangan Media Augmented Reality Untuk Melatih

Keterampilan Berpikir Abstrak Siswa SMA pada Materi Medan Magnet. *PENDIPA Journal of Science Education*, *6*(1), 80–87. https://doi.org/10.33369/pendipa.6.1.80-87

Saltus, R., & Nair, M. (2017). The CrowdMag App – turning your smartphone into a travelling magnetic observatory. *EGU General Assembly 2017*. Retrieved from https://ui.adsabs.harvard.edu/abs/2017EGUGA..19.9916S/abstract

Saltus, R., & Nair, M. (2020). CrowdMag for personal interaction with Arctic magnetic variation. *22nd EGU General Assembly*. https://doi.org/10.5194/egusphere-egu2020-11764

Santoso, D. (2002). *Pengantar Teknik Geofisika*. Bandung: Penerbit ITB.

Soeharto, T. (2022). Pemanfaatan Media Pembelajaran "Micopascien" Untuk Meningkatkan Pemahaman Konsep Magnetisme. *Jurnal Lingkar Mutu Pendidikan*, *19*(1), 1–10. https://doi.org/10.54124/jlmp.v19i1.56

Sudijono, A. (2012). *Pengantar Statistik Pendidikan*. Raja Grafindo.

Supranto, J. (2003). *Metode penelitian hukum dan statistik*. Yogyakarta: Rineka Cipta.

Uspensky, M. (2020). Using Smartphone Sensors To Monitor Geomagnetic Conditions In A Power System Region. *Science Index*, 138–145.

Wang, Y., Kuang, J., Liu, T., Niu, X., & Liu, J. (2024). CrowdMagMap: Crowdsourcing-Based Magnetic Map Construction for Shopping Mall. *IEEE Internet of Things Journal*, *11*(3), 5362–5373. https://doi.org/10.1109/JIOT.2023.3305840