RESEARCH ARTICLE

Developing school laboratory activities design by utilizing android-based digital applications in savanna ecosystem of Ranca Upas

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Abstract: Smartphone utilizing in learning was widely implemented in the digital technology era. This research aims to utilize Android-based digital applications to develop laboratory activity designs in the savanna ecosystem of the Ranca Upas, Ciwidey, West Java. The descriptive method was used to analyze the quality of existing laboratory activity design and develop alternative laboratory activity design to support student practicum. The reconstruction explanation was carried out following the stages analyze, create, try, and reconstruct (ANBUCOR). The initial stage involved analyzing laboratory activity design from the aspects of curriculum, competence, practicality, and knowledge construction. The pilot test showed that the Android digital application provided clear and systematic guidance for students in laboratory activities, with features for measuring abiotic factors, species identification, and observation notes. Based on the feasibility analysis according to the Vee diagram. Laboratory activity design is classified as feasible but requires adjusting the objects identified in the procedure and leading questions with focus questions. Final reconstruction was conducted based on the test team's feedback and Vee diagram analysis. The results showed that the application made the practical learning more interactive and improved students' understanding of the savanna ecosystem. The revised laboratory activity design serves as an effective reference for teachers and students in out-of-class laboratory activities.

Keywords: android-based digital application; laboratory activity design; Ranca Upas; savanna

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Introduction

In the last few decades, advances in information and communication technology have brought significant changes in various areas of life, including education (Isaacs, 2012; Muzana et al., 2021). In this digital era, the use of technology is not only limited to aspects of educational administration and management, but has also penetrated into the learning process itself (Danniels et al., 2020; Prahani et al., 2022). One innovation that is now starting to be implemented in the world of education is the use of Android-based digital applications (Booton et al., 2023; Marsuki et al., 2021; Widiansyah et al., 2018). It offers various conveniences and advantages, especially in presenting interactive and interesting learning material for students (Miangah & Nezarat, 2012; Rusu & Tudose, 2013). Android smartphone applications have been widely used in everyday life, including in the educational process. The use of smartphone applications to improve the quality of learning has become a trend and is widely used by teachers. The use of smartphones in the educational process is one part of learning media. Smartphone functions are optimized to support and present learning material (Malik & Ubaidillah, 2021).

Several forms of smartphone conversion in the learning process are multimedia-based learning media (Arista & Kuswanto, 2018; Fradika & Surjono, 2018; Saputra & Kuswanto, 2019), digital pocket book-based learning media (Astuti et al., 2018; Setiyani et al., 2019), facilities supporting practicum activities (Monteiro et al., 2015; Septianto et al., 2017; Staacks et al., 2018), online classes (Coca & Slisko, 2013; Wang et al., 2019), online conferences (Chuntala, 2019; Mueller et al., 2012) and learning evaluation

(Huang & Chiu, 2015; Shi et al., 2016). The use of smartphones in learning generally still focuses on learning in regular classes. Meanwhile, in biology learning or science learning, there is generally another learning space, namely a laboratory where students can explore through experimental activities (Sulistianingsih & Carina, 2019). As one of the learning innovations, the use of Android smartphone applications in laboratory activities is considered to be very helpful for teachers and students during learning, provided that adjustments to learning activities in the laboratory are required (Fitriani et al., 2018; Saputra & Kuswanto, 2019).

Laboratory activities can develop scientific knowledge through investigation and inquiry activity of natural facts and phenomena (Gibson & Cooper, 2017; Sofiani et al., 2018). Biology learning is not only about learning knowledge, but also a process of providing learning experiences to gain knowledge. Therefore, practical activities are an important part of biology learning (Çimer, 2012; Ping et al., 2020). Through practicum activities in the laboratory, students will be more motivated to learn due to involvement and engaging learning process. Some researchers believes that students will be engage on their study in accordance with the scientific approach (Rosada et al., 2017). Practical work in the laboratory is a learning and teaching activity that involves students in observation, manipulation of objects and real materials and provides hands-on experience that links two domains of knowledge, namely the object and observable domain and the mind domain (Millar, 2004).

Laboratory-based learning activities are learning that can develop students' cognitive, psychomotor and affective aspects (Malik & Ubaidillah, 2021; Rusu & Tudose, 2013). Laboratory activities are designed to help students gain knowledge and understanding of the subject. According to Suryaningsih (2017), learning with practical activities allows students to master concepts, facts and scientific processes thereby improving students' skills. Laboratory facilities and infrastructure are also needed to support practicum activities, so that practicum activities can run smoothly. Generally, there are difficulties in implementing practice-based learning activities such as verification, inquiry laboratories, problem solving laboratories, and higher-order level thinking laboratories. Each model of laboratory activity has criteria and focus for its implementation (Fajarianingtyas & Hidayat, 2020; Lepiller et al., 2017; Ubaidillah, 2016).

One of the laboratory activities is direct practicum in nature. The biggest biology laboratory is nature, one of the natural areas that can be used as a laboratory for practicum students is the savanna Ranca Upas Ciwidey, Bandung. Savanna is grassland and shrubs scattered among the grass, and is a transitional area between forest and grassland. In some areas that are not so dry, savannas may occur due to soil conditions and/or repeated fires. Savanna areas are generally threatened by economic exploitation, however, savannas sometimes come under pressure in the form of tourists crossing the savanna. Savanna is an unstable eco system, its balance depends on climate and humans. In general, savannas experience longer periods of drought than forests. The Ranca Upas is a location that has a unique savanna ecosystem and is rich in biodiversity. This ecosystem offers great potential as a natural laboratory for biological learning, especially in the study of ecology and biodiversity. However, the use of this area as a field practicum location often faces various challenges, such as accessibility, geographical conditions, and the availability of supporting facilities. Therefore, an innovative approach is needed to maximize the use of the Ranca Upas area as a learning resource.

In reality, practical activities in schools are often not optimal. It is not uncommon for many schools to be unable to provide the necessary practicum equipment and materials. Due to the many problems involved, these include inadequate laboratory facilities and infrastructure, insufficient materials and tools, insufficient practicum manuals, very few practical worksheets that depend on teacher and student guidelines, irregular practicum schedules, and limited study time (Tampi et al., 2024). Previous research also discussed the problem of facilities used in schools, problems that occur in the field, most of the facilities used in practicums in schools have limited use of practical tools and materials in biology laboratories, equipment and materials are not all available, there are even some tools that damaged (Aliyah & Puspitasari, 2022). This often results in laboratory activities being less than optimal and not providing the maximum learning experience for students. So, efforts are needed to develop laboratory activity designs using simple tools and materials.

Android-based digital applications can be an effective solution (Booton et al., 2023; Fitriani et al., 2018; Zafrullah et al., 2023). It provide various features that support laboratory activities, such as experimental simulations, interactive guides, and documentation of observation results. Thus, digital applications can help overcome various obstacles that are often faced in biological laboratory activities (Prahani et al., 2022). Apart from that, the use of digital applications can also increase students' interest and motivation in studying biology, because the material presented becomes more interesting and interactive. Effective use of laboratories is one of the requirements in biology learning, especially in practical material. However, in reality not all schools can carry out practicums in accordance with curriculum demands (Dewi et al., 2019). Utilizing Android-based digital applications in designing biological laboratory activities in the Ranca Upas savanna ecosystem can be an effective solution. This application can provide various information and guidance needed to carry out field practicums, such as species identification, interactive maps, and work procedures. In this way, students can prepare themselves better before carrying out practicum, and can make observations and record data more easily and accurately. This research aimed to develop a design for biology laboratory activities in the Ranca Upas, Ciwidey by utilizing digital applications on Android smartphones to overcome the limitations of tools and practical guides available in schools.

Method

This research was development research using the ANBUCOR approach consisting of the stages of analysis, creation, trial, and reconstruction (Riyaldi et al., 2021) to develop laboratory activity designs. This research aimed to utilize android-based digital applications to develop the design of school laboratory activities in the savanna ecosystem of the Ranca Upas. The research process involved several stages: planning in the form of laboratory activity design analysis, nature observation, laboratory activity design making, testing, and final reconstruction. In the planning stage, researchers designed laboratory activities that could utilize the savanna ecosystem as a learning resource. At this stage, researchers also considered the curriculum as the main reference for laboratory activity design (LAD) reconstruction. Natural observations were conducted to identify the area's biodiversity and relevant ecological phenomena. Researchers revised the activity design based on the observation results to ensure its suitability for field conditions.

The initial phase was conducted by implementing the revised activity design in an out-of-class practicum session with other teams that consists of ten students selected by convenience sampling. The results of this trial showed that using Android-based digital applications can provide clear and systematic guidance to students in conducting laboratory activities in savanna ecosystems. The application is equipped with features that can be used to measure abiotic factors of savanna vegetation (i.e. temperature, humidity, light intention, wind velocity, and soil pH), species identification, and observation notes, which greatly help students collect and analyze field data.

The final reconstruction was done by improving and refining the laboratory activity design based on the feedback obtained during the pilot test. The feedback was collected through the team that was consist of ten students. The feedback was a description that can be seen in Table 4. It's also done based on a Vee Diagram analysis by Novak & Gowin (1984) to analyzed the suitability and feasibility. The analysis was carried out to ensure that the laboratory activity design that had been made could appropriately assist students and teachers in clarifying the nature and purpose of practicum procedures, especially in helping students to construct knowledge. The scoring criteria can be seen in Appendix 1**.**

Furthermore, the score obtained from the analysis based on the Vee Diagram scoring guide by Novak and Gowin (1984) was converted into a value using the Formula 1 and categorized based on the eligibility criteria expressed by Table 1.

$$P = \frac{F}{N} \times 100\% \quad (1)$$

Description:
P = Total percentage of scores
F = Total score obtained
N = Total maximum score

Table 1. LAD feasibility categorization

Range of Score (%)	Criteria
81 – 100	Highly Feasible
61 – 80	Feasible
41 – 60	Adequate
21 – 40	Less Feasible
0 – 20	Not Feasible

After the reconstruction phase, the LAD finally serve as an effective reference for teachers and students when conducting laboratory activities outside the classroom. This android-based digital application facilitates more interactive and interesting practical learning and increases students' understanding of the Ranca Upas savanna ecosystem.

Results and Discussion

Analysis stage

The first step in the analysis stage is the initial analysis, which aims to identify the problems and needs that exist in school laboratory activities. There are several problems, especially problems with the limitations of laboratory tools and materials. Laboratory activities are often constrained by the limitations of the tools and materials available. The existing laboratory equipment is not always sufficient to support all students. The second step is curriculum analysis, which aims to adjust the application development to the basic competencies and teaching materials that have been set in the curriculum. The analysis includes review of basic competencies, identifying basic competencies that are relevant to the savanna ecosystem and laboratory activities to be developed. These basic competencies include an understanding of ecosystems, biodiversity, and interactions between living things and their environment and adjustment of teaching materials, determining teaching materials that are in accordance with these basic competencies, and how this material can be delivered effectively through digital applications. The materials developed include theory, practical procedures, and evaluation. The results of this analysis stage provided a strong basis for the development of laboratory activity designs based on digital applications. Identification of problems and needs in the field, adjustments to the curriculum, and understanding of student characteristics are the main foundations in designing effective and efficient applications. Thus, the design of the laboratory activities that will be developed is expected to be able to overcome various existing obstacles and provide a better learning experience for students in studying the material on savanna ecosystems in Ranca Upas.

Laboratory activity design creation

The LAD was designed through an android-based digital application. This stage involved several main aspects i.e. designing learning materials that are prepared comprehensively including theories about savanna ecosystems, biodiversity and ecological interactions. Moreover, the practical procedures were designed to suit existing tools and materials (Figure 1.a). Researchers strived to continue providing relevant practical experience through Android-based digital applications and guiding students conducting the experiments (Figure 1.b). The designs that have been developed are then implemented and tested by other teams. After the trial, an evaluation stage was carried out to measure the effectiveness of the application in increasing students' understanding of the savanna ecosystem.

Tujuan

1. Mengukur profil faktor abiotik ekosistem Sayana di kawasan Ranca Upas.
2. Mengidentifikasi keanekaragaman vegetasi herba di Sayana Ranca Upas.
3. Mengaitkan profil abiotik terhadap keanekaragaman vegetasi herba di Sayana Ranca Upas.

Alat dan Bahan

1.	Kuadran 1m x 1m	1 buah
2.	Aplikasi iNaturalist	1 buah
3.	Aplikasi Lux Light Meter	1 buah
4.	Aplikasi Hygro-thermo meter	1 buah
5.	Meteran	1 buah
6.	Soil pH Tester	1 buah
7.	Aquades	600ml
8.	Aplikasi Anemometer "Angin"	1 buah
9.	Tali rafia	1 gulung besar
10.	Kantong plastic	1 pack
11.	Alat tulis	1 pack

(a)

Biotik:

Keanekaragaman vegetasi herba di Ekosistem Sayana Ranca Upas:

1. Letakkan kuadran (bisa diganti tali rapia dan meteran jika kuadran tidak ada) 1mx1m secara random pada ekosistem sayana
2. Identifikasi tumbuhan apa saja yang ada di dalam plot 1mx1m menggunakan aplikasi **iNaturalist**
3. Inventarisasi semua tumbuhan yang ditemukan dan teridentifikasi dalam plot 1mx1m
4. Setelah inventarisasi spesies, ukurlah faktor abiotik yang ada di dalam plot 1mx1m.
5. Faktor abiotik yang diukur adalah Faktor Klimatik meliputi: suhu udara, kelembapan udara, kecepatan angin, serta intensitas cahaya; dan faktor edafik meliputi: pH tanah, kelembapan tanah dan suhu tanah.
6. Ulangi langkah 1-5 di tempat yang berbeda secara random dalam satu ekosistem sebanyak 3x titik sampel random
7. Setelah itu, masukkan data yang didapat kedalam tabel pengamatan berikut ini:

Titik Sampel	Spesies yang ditemukan	Faktor Klimatik				Faktor Edafik		
		Suhu	Kelembapan	Intensitas Cahaya	Kecepatan Angin	Suhu Tanah	pH Tanah	Kelembapan
Titik Sampel 1	1. 2. 3.							
Titik Sampel 2	1. 2. 3.							
Titik Sampel 3	1. 2. 3.							

(b)

Figure 1. The LAD features: (a) Objectives and tools and materials; (b) Biotic factor procedure

The design of this laboratory activity was made by referring to the Independent Curriculum (Kemendikbudristek, 2022), especially the ecosystem sub-component, to provide a relevant and in-depth learning experience for students (Bertrand & Namukasa, 2023; Nandana & de Mel, 2016). The aim of this research experience includes three main aspects i.e. (a) measuring the abiotic factor profile of the savanna ecosystem, includes analysis of environmental parameters such as temperature, humidity and soil pH; (2) identifying the diversity of herbaceous vegetation, which involves collecting data on the types of herbaceous plants and their distribution in the area; and (3) linking abiotic profiles to the diversity of herbaceous vegetation (Figure 2.a), to understand how environmental factors influence the diversity and distribution of herbaceous plants in savanna ecosystems.

To achieve that goal, tools and materials have been listed in detailed quantities to ensure all practicum needs are met and can be carried out properly (Figure 1.a). The research procedures are designed in detail and clearly so that students can follow and understand each step easily. The instructions provided include the use of tools, sampling, and the necessary data analysis techniques. In addition, we also develop focused questions designed to guide students in gaining in-depth knowledge (Figure 2.b). These questions are designed to stimulate students' critical thinking and in-depth analysis, so students not only collect data but also understand the context and implications of their results. With this approach, it is hoped that students can develop strong scientific skills, such as observation, data analysis, and drawing conclusions, which are very important in the study of ecology and environmental science.

Abiotik:

a. Faktor Klimatik

1. Intensitas Cahaya
   - Buka aplikasi Lux Light Meter kemudian mencatat hasil pengukuran cahaya yangotomatis sudah terukur oleh aplikasi.
2. Kecepatan Angin
   - Buka aplikasi anemometer "Angin" lalu melihat pengukuran yang otomatis terdeteksidengan satuan km/h.
3. Suhu dan Kelembapan
   - Buka aplikasi Hygro-thermo meter lalu klik bagian "temperature" untuk mengukursuhu. Selanjutnya klik bagian "humidity" untuk mengukur kelembapan udara.

b. Faktor Edafik

1. pH dan kelembapan tanah
   - Kalibrasi alat soil tester menggunakan aquades sehingga pH nya normal
   - Pilih salah satu spot dalam kuadran untuk digali tanahnya sekitar 3cm
   - Tancapkan soil tester pada sampel tanah selama 30 detik dan akan muncul besaran pH
   - Selang 5 menit, dilakukan pengulangan dengan sampel tanah yang berbeda, namun masih dalam 1 kuadran
   - Gunakan indikator pH universal jika diperlukan
2. Suhu tanah
   - Tanah digali dengan kedalaman 10cm
   - Tancapkan termometer ke dalam tanah yang sudah digali
   - Diamkan selama 15 menit lalu amati angka yang muncul pada skala termometernya

(a)

Pertanyaan:

1. Apa saja jenis tanaman yang dapat diamati pada vegetasi savana Ranca Upas?
2. Berapa jumlah masing-masing spesies tersebut?
3. Tanaman apa yang paling mendominasi wilayah savana Ranca upas?
4. Bagaimana bentuk morfologi tanaman yang ditemukan di savana? Apa ciri khusus yang ditemukan?
5. Bagaimana kondisi komponen abiotik di ekosistem savana? Berapa intensitas cahaya kecepatan angin, suhu dan kelembapannya?
6. Bagaimana kondisi tanah pada ekosistem savana? Berapa pH, kelembapan tanah, dan suhu tanahnya?
7. Mengapa tanaman yang ditemukan dapat tumbuh dengan baik di ekosistem savana?
8. Apakah ciri morfologi dapat berpengaruh terhadap kemampuan hidup tanaman di savana?
9. Apakah terdapat interaksi antar komponen biotik dan abiotik pada ekosistem savana? Bagaimana bentuk interaksi yang dilakukan antara komponen tersebut?
10. Apa kesimpulan yang didapatkan setelah melakukan praktik lapangan tersebut?

(b)

Figure 2. The LAD features: (a) Abiotic factor procedure; (b) Question

Laboratory activity design trial results

The results of the pilot test are the basis for design evaluating of the laboratory activities. The trial was conducted by another team who provided an overview and input for reconstruction. Data from the initial laboratory activity design trials are presented in Table 2.

Table 2. Initial LAD trial result data by students

Repetition	Dominant Species	Climatic Factor				Edaphic Factor
		Temp (ºC)	Humidity (%)	Light Intention (Lux)	Wind Velocity (km/h)	Soil pH
Sample place 1	1. *Poa trivialis* 2. *Alternanthera philoxeroides* 3. *Hydrocotyle sibthorpioides*	26	80	630	16	5.8
Sample place 2	1. *Poa trivialis* 2. *Alternanthera philoxeroides* 3. *Hydrocotyle sibthorpioides*	26	80	682	16	5.8
Sample place 3	1. *Alternanthera philoxoroides* 2. *Poa trivialis* 3. *Hydrocotyle sibthorpioides*	26	80	612	18	6

The results of the initial laboratory activities design was provided consistent data on dominant species, climatic factors, and edaphic factors in the savanna ecosystem of the Ranca Upas. The dominance of species such as *Poa trivialis*, *Alternanthera philoxeroides*, and *Hydrocotyle sibthorpioides* at each sample point indicates the vegetation homogeneity. Climatic factors such as temperature, humidity, light intensity, and wind velocity showed fairly stable conditions at the various sample points, with an average temperature (26ºC), humidity (80%), light intensity varying between 612 to 682 lux, and wind velocity consistent at 16-18 km/h. Edaphic factors such as soil pH also showed little variation, with pH ranging from 5.8 to 6.

This data confirmed that the applied LAD could provide clear and accurate guidance in measuring the condition of savanna ecosystems and improve students' understanding of the interactions between abiotic and biotic components in these environments. In addition, the android-based digital application used in this activity showed its effectiveness in providing structured and easy-to-follow instructions for students (Figure 3). The features in the app such as abiotic factor measurements, species identification, and observation notes not only helped in data collection and analysis, but also increased student engagement in the practicum activities (Miller et al., 2021; Unger et al., 2021). It can be seen from the positive response to the use of technology in learning which makes the learning process more interactive and interesting. The use of technology also allowed for more efficient data storage and access, making it easier for teachers and students to track observations and analyze ecosystem changes over time.

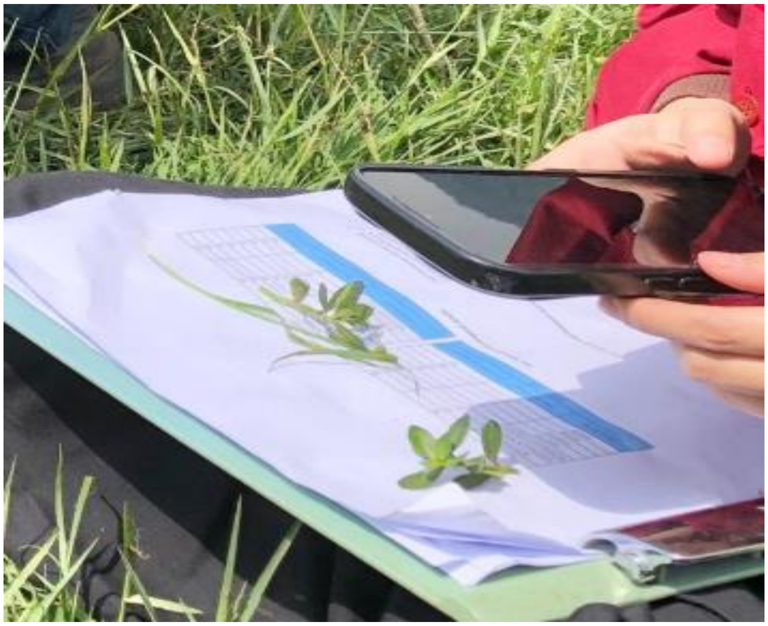

Figure 3. Initial laboratory activity design trial process

The test team also provided some suggestions and feedback for the final reconstruction. Some of the suggestions included using several similar applications to produce more accurate and appropriate data, for example by combining the *PlantNet* as a complement to the *iNaturalist* application. The use of multiple applications is expected to enrich the data and provide cross-verification to increase its reliability (Echeverria et al., 2021; Hernawati et al., 2020; Unger et al., 2021). In addition, the trial team recommends adding a more detailed documentation table, which includes data related to morphological traits and other information on each species found.

The addition of this information aims to provide students with a deeper understanding of biodiversity in savanna ecosystems. By including morphological data and other specific information, students can learn to recognize and understand the unique characteristics of each species (Gifford & Nilsson, 2014). It is not only enriches their learning experience, but also helped in more structured and systematic data collection during laboratory activities (Serrat et al., 2014; Sofiani et al., 2018). The implementation of these suggestions was expected to improve the design of the laboratory activity so that it became a more comprehensive and effective reference for learning activities in the field.

Effectiveness of using digital application in practicum activities

Environmental factors are certainly a factor in the emergence of the diversity of herbaceous vegetation in savanna ecosystem, one of which is climatic factors and edaphic factors. The environmental factor was measured through laboratory instrument such as lux meters, anemometers, and hygro-thermometers. Apart from that, edaphic factors also need to be tested, such as pH and soil moisture using a soil tester, as well as soil temperature measured using a thermometer. However, the limitations and efficiency of practical tools in the field can be overcome with digital measuring tools so that it is enough to just bring a smartphone. However, several things need to be considered when using each downloaded application. The following are research results that can be considered in every application that will be used by students in measuring climatic factors.

a) *Lux Meter.* Lux meter is used to measure the intensity of light in a predetermined quadrant area. The measurement results will appear automatically. However, (Herzog et al., 2022) revealed that measurements using smartphones gave rise to unreliable lighting measurements. In this case, apart from low precision, the calibration carried out is also unclear. However, this digital tool is sufficient for use in home-scale measurements such as for plant growth activities, photography purposes, and student practical activities. Another thing that needs to be taken into account is the deviation in light detection by the cellphone. The light source captured by the directional position of the smartphone is taken into consideration. Calibration with accurate measurements will likely be comparable to the measurement results from standard lux if the position of the cell phone at the time of measurement is in the same direction.

b) *Anemometer.* The results of wind speed measurements in the area under study will appear automatically in the anemometer application. Limited equipment and relatively expensive prices give rise to other alternatives to use Android-based anemometers, but their application still prioritizes adaptive control and is of course integrated with the environmental temperature in the area studied (Katriani et al., 2017). The principle in determining wind speed is to detect a flow of changes in the physical condition of a fluid. This is done because wind has speed, direction and energy. The direction of the wind will give rise to a degree that indicates whether the wind is weak, very weak, or even no wind at all. Meanwhile, wind speed is expressed in units of km/hour. The faster the wind, the greater the energy it carries. These parameters can be detected directly by the anemometer application in an instant, you only need skills in how to position the cellphone so that the calibration and results that appear have high precision like a regular anemometer.

c) *Hygro-Thermometer.* Temperature and humidity can be measured simultaneously. However, Android-based applications make the cellphone a multifunctional instrument. In this measurement, it would be better if there was a probe, but many applications do not use a probe. The new thing that students get is that the results obtained can be converted to calculate air speed using the mobile meter mobile application if necessary. The advantage of using an application is how the measurement results from an application can be integrated to measure other parameters.

Apart from abiotic factors, in existing biotic analysis, students can use the *iNaturalist* to elaborate on their findings for both animals and plants. The use of this application is considered quite effective (Hernawati et al., 2020). Students who use *iNaturalist* have the opportunity to communicate with experts and researchers around the world. This is in line with increasing collaboration as a scientific community. The central database on *iNaturalist* provides students an opportunity to store and upload their research findings. In this way, students can simultaneously learn about taxonomy in different ways. However, the variety of features in this application requires teachers to be able to maximize the use of *iNaturalist* so that what students do is effective, efficient and maximal. However, students are allowed to use other applications such as *PlantNet* to assist in ensuring the accuracy of the detection results displayed (Guo & Gao, 2017).

Analysis of suitability and feasibility of laboratory activity design

The LAD used in the trial process was analyzed for suitability and feasibility based on the Vee Diagram expressed by Novak & Gowin (1984). The analysis was carried out to ensure that the laboratory activity design that had been made could appropriately assist students and teachers in clarifying the nature and purpose of practicum procedures, especially in helping students to construct knowledge. The scoring results presented in Table 3.

Table 3. Scoring results of LAD analysis assessment based on Vee diagram

No	Aspects	Score	Description
1.	Focus question	3	Focus question identified and can be used to generate appropriate events and data.
2.	Object/Event	1	Key events identified but not consistent with focus question.
3.	Theory/Principle/Concept	4	Concepts and principles (conceptual and procedural) and relevant theories identified
4.	Record/Transformation	1	Record identified but not consistent with focus question/event
5.	Knowledge Claim	2	Knowledge claims include concepts that can be used to generalize but are not consistent with records and transformations.
	Total Score	11	

Based on the results of the score calculation using the LAD feasibility percentage formula that we explain before in methods section, the laboratory activity design that has been designed is categorized as feasible to use for practicum activities in schools (P = 61.11%). This LAD includes clear guidance on the focus question and theoretical foundations. However, it has not yet fully achieved the clear object/event, record transformation, and knowledge claim (Table 4). While each of these elements plays a crucial role in helping students understand the core concepts of the practicum while also promoting active learning and critical thinking.

Table 4. The detailed descriptions of the components that have been analyzed

No	Aspects	Description
1	Focus question	▪ There is a focus question written in the practicum title, "*How does abiotic profile affect herbaceous vegetation diversity in savanna Ranca Upas*?" ▪ The students will get facts in the field, such as abiotic factors, which can transform students' factual knowledge into conceptual knowledge through the procedural steps in LAD. ▪ The focus question formulated can also be used to generate events and data accordingly. Focus question is the most essential thing in practicum activities that can be found in the title, practicum objectives, or problem formulation serve to direct practicum activities to focus on certain events or objects and play a role in helping students to collect data to construct knowledge (Novak & Gowin, 1984)
2	Object/Event	▪ Objects and events can be observed from the practicum procedures and guiding questions in the LAD ▪ In the focus question, the object that appears is the abiotic profile and diversity of herbaceous vegetation in the savanna area and the event is the interaction of the two objects
3	Theory/Principle/Concept	▪ Relevant concepts, principles (conceptual and procedural) and theories are identified in the introduction, lab procedures, and guiding questions. Principles, theories, or concepts related to this practicum activity include: - The concept of species diversity and abiotic factors - Principles of biotic-abiotic interactions and adaptation - Ecosystem ecology theory (Angreani et al., 2022; Hayat et al., 2011)
4	Record/Transformation	▪ The record part can be identified in the observation table listed in the practicum procedure ▪ The observation table doesn't line with the initial focus question ▪ The stages of data transformation listed in the leading question do not require students to gain their knowledge gradually. ▪ The questions related to the interaction between biotic and abiotic components found were only expressed in one question.
5	Knowledge Claim	▪ Include concepts that can be used to generalize practicum results ▪ The knowledge claim obtained in the practicum is the concept of savanna abiotic profile and herbaceous plant diversity

Overall, the LAD made is good and in accordance with the provisions of the Vee Diagram (Novak & Gowin, 1984). There is only a mismatch in the object identified in the practicum procedure and leading questions with the object that is the focus of the focus question listed in the title. Improvements related to this can improve the laboratory activity design that has been made so that it can guide students' knowledge according to the focus question and the desired goal.

Reconstruction of Laboratory Activity Design

The results of the final reconstruction of the LAD were carried out by considering feedback from the pilot team, various improvements have been made, including the integration of several digital applications for data verification, the addition of more detailed documentation tables, as well as information on morphology and specific characteristics of each species found. Data analyzed using Vee Diagrams also contributed to the reconstruction of the final laboratory activity design. This update not only enriches the learning content but also improves interactivity and student engagement in laboratory activities. Reconstruction results are presented in Table 5.

After the final reconstruction, the tools and materials section in the laboratory activity design was updated to ensure completeness and ease of use during field activities in the savanna ecosystem of Ranca Upas Area. Muchsin et al (2021) was found that, although the practical aspects of LAD in various curricula are often effective, other areas still need further improvement. Enhancements to LAD were illustrated in a table of modified tools, which now includes additional devices and applications to support species measurement and identification. The table of tools used has been adjusted with the addition of devices and applications that support measurement and species identification (Gultepe, 2016; Peffer et al., 2015). The tools prepared include stationery, mobile phones equipped with iNaturalist and PlantNet applications for species identification, 1m^2 of quadrants, as well as Lux Light Meter, Hygro-thermometer, and Wind Anemometer applications for abiotic factor measurements. The use of tools from the *iNaturalist* application has become a valuable tool in biodiversity education and citizen science, with research highlighting its role in engaging students in outdoor learning, improving species identification skills, and supporting collaborative learning (Echeverria et al., 2021; Unger et al., 2021) and the tools android-based PlantNet application to identify plant species can not only help botanists in carrying out their work but also help educators and students to make it easier to identify plant species (Guo & Gao, 2017).

Table 5. The reconstruction of LAD design

<table>
<tr><th>Components</th><th>After Revision</th></tr>
<tr><td>

The initial objectives and theoretical basis.
The initial objective focuses on measuring abiotic factors and identifying the diversity of herbaceous vegetation in Ranca Upas Savannah so that students are expected to be able to relate the two conditions.

</td><td>

B. Tujuan
1. Mengukur profil faktor abiotik ekosistem Savana di kawasan Ranca Upas.
2. Mengidentifikasi keanekaragaman vegetasi herba di Savana Ranca Upas.
3. Mengaitkan profil abiotik terhadap keanekaragaman vegetasi herba di Savana Ranca Upas.

C. Kajian Teori
Savana merupakan padang rumput dan semak yang terpencar di antara rerumputan, serta merupakan area peralihan antara hutan dan padang rumput. Di beberapa area yang tidak begitu kering, savana mungkin terjadi karena keadaan tanah dan atau kebakaran yang berulang. Kawasan savana pada umumnya terancam oleh eksploitasi ekonomi, meskipun demikian savana kadang-kadang mendapat tekanan berupa wisatawan yang melintasi savana. Savana merupakan ekosistem yang kurang stabil, keseimbangannya tergantung iklim dan manusia. Pada umumnya savana mengalami masa kekeringan lebih panjang dari pada hutan.
Keberadaan bahan organik dan tumbuhan pada ekosistem savana menyebabkan terjadinya interaksi antara komponen biotik dan abiotik. Interaksi yang terjadi pada ekosistem savana akan diamati di Rancaupas. Pengamatan yang dilakukan adalah analisis profil komponen biotik dan abiotik dari ekosistem savana. Pada komponen biotik yang diamati adalah keanekaragaman vegetasi herba di savana. Pada komponen abiotik akan dianalisis faktor klimatik, dan edafik. Pengamatan faktor klimatik yang terdiri atas suhu udara, kelembapan udara, kecepatan angin, serta intensitas cahaya. Pengamatan faktor edafik diamati adalah menganalisis pH tanah, kelembapan tanah dan suhu tanah.
</td></tr>
<tr><td>

The tools and materials
This part is often forgotten by teachers, but we need to train students to be able to distinguish between these two components.

</td><td>

D. Alat dan Bahan
Tabel 1. Alat yang digunakan
<table>
<tr><th>No.</th><th>Alat</th><th>Jumlah</th></tr>
<tr><td>1.</td><td>Alat tulis</td><td>1 unit</td></tr>
<tr><td>2.</td><td>Handphone</td><td>1 unit</td></tr>
<tr><td>3.</td><td>Kuadran 1m x 1m</td><td>1 unit</td></tr>
<tr><td>4.</td><td>Aplikasi iNaturalist dan PlantNet</td><td>1 unit</td></tr>
<tr><td>5.</td><td>Aplikasi Lux Light Meter</td><td>1 unit</td></tr>
<tr><td>6.</td><td>Aplikasi Hygro-thermo meter</td><td>1 unit</td></tr>
<tr><td>7.</td><td>Meteran</td><td>1 unit</td></tr>
<tr><td>8.</td><td>Soil pH Tester</td><td>1 unit</td></tr>
<tr><td>9.</td><td>Aplikasi Anemometer "Angin"</td><td>1 unit</td></tr>
</table>
Tabel 2. Bahan yang digunakan
<table>
<tr><th>No.</th><th>Alat</th><th>Jumlah</th></tr>
<tr><td>1.</td><td>Aquades</td><td>600 ml</td></tr>
</table>
</td></tr>
<tr><td>

Changes explanation of edaphic factors in the form of points

</td><td>

2.2 Faktor Edafik
2.2.1 pH dan Kelembapan Tanah
1) Kalibrasi alat soil tester menggunakan aquades sehingga pH nya normal.
2) Pilih salah satu spot dalam kuadran untuk digali tanahnya sekitar 3cm.
3) Tancapkan soil tester pada sampel tanah selama 30 detik dan akan muncul besaran pH.
4) Selang 5 menit, dilakukan pengulangan dengan sampel tanah yang berbeda, namun masih dalam 1 kuadran.
5) Gunakan indikator pH universal jika diperlukan.

2.2.2 Suhu Tanah
1) Tanah digali dengan kedalaman 10 cm.
2) Tancapkan termometer ke dalam tanah yang sudah digali.
3) Diamkan selama 15 menit lalu amati angka yang muncul pada skala termometer.
</td></tr>
</table>

<table>
<tr><th>Components</th><th>After Revision</th></tr>
<tr><td>

- The observation table,
- It is design to facilitate students to mapping the obtained data

</td><td>

F. **Hasil Pengamatan**

Tabel 3. Hasil Pengamatan Keanekaragaman Tanaman Herba di Ranca Upas

<table>
<tr><th>Plot</th><th>No</th><th>Dokumentasi</th><th>Nama Spesies</th><th>Ciri-Ciri Morfolofi</th><th>Divisio dan Kelas</th><th>Jumlah Spesies</th></tr>
<tr><td rowspan="3"></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Tabel 4. Hasil Pengamatan Profil Abiotik Kawasan Ekosistem Savana

<table>
<tr><th rowspan="2">Plot</th><th rowspan="2">No</th><th rowspan="2">Dokumentasi</th><th rowspan="2">Nama Spesies yang Ditemukan</th><th colspan="4">Faktor Klimatik</th><th colspan="3">Faktor Edafik</th></tr>
<tr><th>Suhu</th><th>Kelembapan</th><th>Intensitas Cahaya</th><th>Kecepatan Angin</th><th>Suhu Tanah</th><th>pH Tanah</th><th>Kelembapan</th></tr>
<tr><td rowspan="2"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

</td></tr>
<tr><td>

- Questions and conclusion to LAD
- Each question is a stimulus that needs to be well crafted to fit the learning objectives

</td><td>

G. Pertanyaan untuk Diskusi

1. Apa saja jenis tanaman yang dapat diamati pada vegetasi savana Ranca Upas?
2. Berapa jumlah masing-masing spesies tersebut?
3. Tanaman apa yang paling mendominasi wilayah savana Ranca upas?
4. Bagaimana bentuk morfologi tanaman yang ditemukan di savana? Apa ciri khusus yang ditemukan?
5. Bagaimana kondisi komponen abiotik di ekosistem savana? Berapa intensitas cahaya kecepatan angin, suhu dan kelembapannya?
6. Bagaimana kondisi tanah pada ekosistem savana? Berapa pH, kelembapan tanah, dan suhu tanahnya?
7. Mengapa tanaman yang ditemukan dapat tumbuh dengan baik di ekosistem savana?
8. Apakah ciri morfologi dapat berpengaruh terhadap kemampuan hidup tanaman di savana?
9. Apakah terdapat interaksi antar komponen biotik dan abiotik pada ekosistem savana? Bagaimana bentuk interaksi yang dilakukan antara komponen tersebut?

H. Kesimpulan

Apa kesimpulan yang didapatkan setelah melakukan praktik lapangan tersebut?

</td></tr>
</table>

In addition, a soil pH Tester was also included for soil pH measurement. Materials such as distilled water are also available for measurement purposes. This addition aims to facilitate students in making field observations and measurements systematically and accurately in accordance with the objectives of laboratory activities (Aliyah & Puspitasari, 2022; Gultepe, 2016). The final reconstruction also improved the table to obtain more complete and structured data. Adjustments were made by adding additional columns in the observation data table in order to obtain more detailed information, such as a brief description of the morphological characteristics of each plant species found.

The final reconstruction also improved the observation table to obtain more complete and detailed data. In Table 5, which contains the results of observations, columns have been added that include visual documentation, species names, morphological characteristics, and classification by division and class. It addition was designed to provide a more comprehensive graph of the biodiversity in the observation plot (Nguyen, 2020; Szczytko et al., 2019). The addition of visual documentation allows students to record and refer back to images of species found, while the morphological traits column aids in more accurate species identification. The division and class classification information enriches students' knowledge of plant taxonomy. The number of species recorded in each plot also provides quantitative data that can be used for diversity analysis. All these additions aim to ensure that the observations are not only complete but also easy to analyze and understand, thus improving the quality and accuracy of laboratory activities (Malik & Ubaidillah, 2021; Sofiani et al., 2018).

Conclusion

This study successfully showed that the utilization of Android-based digital applications can improve the quality of LAD in the savanna ecosystem of the Ranca Upas. Through the ANBUCOR stages that include analysis, creation, testing, and reconstruction, the alternative Laboratory Activity Design developed is able to provide clear and systematic guidance in preparing laboratory activity designs. Applications such as iNaturalist and PlantNet facilitate species identification, while Lux Light Meter, Hygro-thermometer, and “Wind” Anemometer applications assist in the measurement of abiotic factors. Trial results showed that the use of these apps not only made learning more interactive and engaging, but also improved students' understanding of savanna ecosystems. With improvements based on feedback, the resulting laboratory activity design becomes an effective reference for teachers and students in carrying out laboratory activities outside the classroom, so it can be adopted to improve students' practical learning field experience.

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Conflicts of Interest

The authors declare no conflict of interest regarding this research. This research was conducted independently without influence from outside parties or institutions that could affect the results or interpretation of the data. The Android-based digital applications used in this study were selected purely based on considerations of their effectiveness and ability to support laboratory activities. No financial or commercial gain was obtained from the use of these applications. All data and research results are presented honestly and transparently, following applicable research ethics standards.

Author Contributions

A. A. Nurahman, and **N. F. Siregar:** conceptualization, introduction and methodology; **S. I. Fadilah., R. P. Cahyani.,** and **N. Hadistia:** results and discussion; **S. I. Fadilah; A. Amprasto, B. Supriatno:** review; and **A. A. Nurahman:** editing article.

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Appendix 1. Rubric of Scoring the Design Laboratory Activity (Novak & Gowin, 1985) page 70-72.

Aspects	Score 0	Score 1	Score 2	Score 3	Score 4
Focus Question	Unidentified focus question	Identified, but not really focus in guiding to the object/event or the conceptual in Vee diagram	Identified, but one of the concepts/objects/events is implemented wrong	Clear and identified, it can be used for guiding to the event and get the relevance data	-
Object/events	Unidentified object/events	Identified, but inconsistent with the focus question	Identified and also consistent with focus question	Identified and consistent with the focus question, also able to conduct and record the data	-
Principle/Concept/Theory	Unidentified concept	Identified concept, but unidentified principle and theory	Identified concept and one of the principle/concept/theories is identifiably relevance	Identified concept and principle, also one of the principle/concept/theories is identifiably relevance	All concept, principle, and theories are identifiably relevance
Record/Transformation	Unidentified data record	Identified data record, but inconsistent with the focus question	One of the data record/transformations identified	Identified data record and based on the object/events, but inconsistent with the focus question	Identified data record and based on the object/events, consistent with the focus question, relevance with the student level
Knowledge Claim	Unidentified knowledge claim	Unrelated with the concept, principle, and theory	Consisted of the concept for generalization, but inconsistent with record and transformation	Consisted of the concept for generalization, also consistent with record and transformation	Consisted of the concept for generalization, consistent with the record and transformation, also able to create the new focus question