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CNN'S TECHNOLOGY INFORMATION MEDIA ON COFFEE BEANS IN PROJECT-BASED LEARNING IN COMPUTER LABS

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ABSTRAK

Coffee beans are one of the most important agricultural commodities in the world. An accurate process of classifying coffee beans is key in ensuring that only high-quality beans reach consumers. Classifying coffee beans is not simple because the process relies on human judgment, which is prone to errors and inconsistencies. Errors in classification will result in a decrease in the value of coffee bean products. In this context, the role of information technology in automating and improving the accuracy of the classification process is urgently needed. This research method is the use of one of the digital technologies, namely CNN for classifying coffee beans, with the aim of determining the effectiveness of using CNN technology to classify coffee beans and knowing the effectiveness of implementing project-based laboratory learning. The results obtained show that the use of CNN has effectiveness with an accuracy rate above 90%, showing its advantages compared to other neural network methods. Then, the effectiveness of using information media that utilizes CNN technology on student learning outcomes was recorded to be very satisfactory, with effectiveness reaching 93.60%.

Keywords : Information Media, Coffee Beans, Classification, CNN

ABSTRACT

Coffee beans are one of the most important agricultural commodities in the world. An accurate process of classifying coffee beans is key in ensuring that only high-quality beans reach consumers. Classifying coffee beans is not simple because the process relies on human judgment, which is prone to errors and inconsistencies. Errors in classification will result in a decrease in the value of coffee bean products. In this context, the role of information technology in automating and improving the accuracy of the classification process is urgently needed. This research method is the use of one of the digital technologies, namely CNN for classifying coffee beans, with the aim of determining the effectiveness of using CNN technology to classify coffee beans and knowing the effectiveness of implementing project-based laboratory learning. The results obtained show that the use of CNN has effectiveness with an accuracy rate above 90%, showing its advantages compared to other neural network methods. Then, the effectiveness of using information media that utilizes CNN technology on student learning outcomes was recorded to be very satisfactory, with effectiveness reaching 93.60%.

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A. Background

In the modern agricultural world, information technology has become the main key in speeding up processes and increasing efficiency, especially in the context of classifying coffee beans. Classifying coffee beans, a critical process that determines the quality and market value of the final product, has long relied on manual appraisals that require high expertise and are often prone to errors. This is where the importance of information technology, particularly in the application of image processing and machine learning methods, such as Convolutional Neural Networks (CNNs), becomes very significant. To speed up the process and increase efficiency in coffee bean classification, the application of image processing and machine learning methods, such as *Convolutional Neural Networks* (CNN), becomes crucial. This is in line with the broader trend of utilizing information technology to improve agricultural practices and contribute to the growth of agricultural enterprises (Hafizar et al., 2022). This technology is important in modern agriculture, which aims to maximize the quality of agricultural products and reduce the risk of crop failure due to inadequate monitoring of crop growth (Ayudewi et al., 2020).

The integration of information technology in modern agriculture has indeed significantly improved the efficiency and accuracy of processes, particularly in the classification of coffee beans. Traditionally, the classification process relied on manual assessment, which was labor-intensive and prone to errors. However, the application of image processing and machine learning techniques, such as Convolutional Neural Networks (CNN), has revolutionized this aspect of agriculture (Murinto, 2023). The utilization of technology not only improves agricultural processes but also facilitates agricultural education and extension services. For example, the use of audio-visual media has been used to improve the competence of human resources (Monica, 2022).

Coffee beans are one of the most important agricultural commodities in the world. The quality of coffee beans determines the flavor profile, aroma, and overall determines the unique coffee drinking experience. An accurate process of classifying coffee beans is key in ensuring that only high-quality beans reach consumers. In this context, the role of information technology in automating and improving the accuracy of the classification process becomes very important. The application of appropriate post-harvest technology is crucial to increase coffee productivity, in line with government policy for the development of post-harvest coffee technology (Mawardi et al., 2019).

Classifying coffee beans is not a simple task. Traditionally, this process relies on human judgment, which, although performed by experts, remains prone to errors and inconsistencies. Assessments are made on various characteristics, including size, shape, color, and integrity of seeds. Errors in classification can result in low-quality coffee beans getting into supply that should be of high quality, which in turn can lower the overall value of the product and damage the manufacturer's reputation. With the increasing market demand for high-quality coffee, the industry must look for ways to improve the classification process to maintain quality standards (García et al., 2019); (Zhang et al., 2019).

The traditional process of coffee bean classification relies heavily on human judgment, which, although carried out by experts, remains prone to errors and inconsistencies. However, technological advances have paved the way for more accurate and automated methods of classifying coffee beans. Information technology, particularly through the use of CNNs, offers advanced solutions in identifying and classifying coffee beans. CNN, which is part of deep learning (*deep learning*), effective in processing image data. With its ability to recognize patterns and visual traits, CNNs can be trained to identify coffee beans based on size, shape, color, and even surface defects. This allows the process of classifying coffee beans to be faster, more accurate, and more consistent than human judgment (Nugroho & Sebatubun, 2020).

The application of information technology such as CNN in classifying coffee beans also brings efficiency on a larger scale. The automated process means that large quantities of coffee beans can be processed in less time, increasing productivity and reducing labor costs (Hafizar et al., 2022). With higher accuracy, a reduction in waste of low-quality coffee beans that are mistakenly classified as high-quality is also achieved, raising overall quality standards (Saputra et al., 2020).

The adoption of information technology in agriculture, particularly in the classification of coffee beans, represents an important paradigm shift. From traditional methods that rely on human judgment, the industry is now moving to more data- and technology-oriented solutions. This shows not only technological advancements, but also new ways of thinking in the face of the challenges of the agricultural industry (Faris &; Wisaksono, 2021).

The use of CNN in classifying coffee beans is a perfect example of how information technology can transform into a driving force in agriculture. With the potential to improve accuracy, efficiency, and consistency, these technologies pave the way for more innovative and sustainable agricultural practices (Syarovy et al., 2023). In the long run, the use of this kind of technology not only has an impact on improving the quality of agricultural products but also on improving farmers' welfare and consumer satisfaction (Z. Chen et al., 2021). The implementation of CNN technology in classifying coffee beans also brings wider benefits to the agricultural sector. With accurate data collection and analysis, this technology enables industry players to make more informed and data-driven decisions (Mawardi et al., 2021). In addition, the application of information technology such as CNN in classifying coffee beans also has the potential to increase transparency and trust in the coffee supply chain. Today's consumers are increasingly aware of the origins and quality of the products they consume. With technology capable of providing accurate information about the quality of coffee beans, manufacturers can offer a higher level of transparency, strengthen consumer trust and build a stronger brand reputation (Murinto, 2023). The application of information technology in agriculture, particularly in the context of classifying coffee beans, reflects the global trend towards digitalization in various sectors (Syarovy et al., 2023). This shows that the integration of information technology in agriculture is a significant step forward towards a smarter and more efficient agricultural future (Profit, 2023).

In the context of computer laboratories, the use of information technology such as CNN for classifying coffee beans not only plays a role in increasing production efficiency, but also as a valuable educational tool. Project-based computer labs provide an ideal platform for developing, testing, and refining CNN algorithms. Students and researchers can experiment with real data, understand practical challenges, and contribute to the development of solutions that can be applied in the real world (Raharjo &; Agustini, 2020). Through projects in computer labs, students and researchers have the opportunity to contribute directly to innovation within the agricultural sector. The role of laboratories in the development and implementation of information technology through projects provides opportunities for students and researchers to contribute directly to innovation. The application of information technology in project management is very important to improve work performance and increase competitiveness (Irnawati, 2021). In addition, the implementation of project-based learning has been shown to improve student activity and learning outcomes in creative product and entrepreneurial subjects (Vidyastuti, 2022). The use of project-based learning not only examines the relationship between information and practice but also motivates students to reflect on what they have learned in real projects (Vidyastuti, 2022). Thus, computer labs serve not only as a place of learning but also as incubators of innovation, where new ideas can be tested, refined, and ultimately implemented in real agricultural practices (Taylor & Amidy, 2020).

So, the application of information technology, particularly CNN, in classifying coffee beans offers significant benefits. From increased efficiency and accuracy to contributions to education and innovation, these technologies mark an important step forward in the evolution of modern agriculture. By implementing these advanced technological solutions, the agricultural industry, particularly the coffee sector, can achieve greater improvements in quality, efficiency, and sustainability, bringing benefits not only to farmers and producers but also to consumers and the environment as a whole.

B. Library Review

a. Information Media Technology

Information media technology is a concept that involves the use of information technology in disseminating, managing, and moving information through various media. This includes the use of the web, social media, system applications, and other platforms in various sectors of community activities including business, education, agriculture and government ((Hermansyah et al., 2022); (Wibowo et al., 2022); (Malini et al., 2021)). Information technology has allowed the existence of diverse media, supported by advances in information technology, which affect the progress of aspects that use information (Satria et al., 2021). In the context of education, information technology plays an important role in the development of learning media, both in the form of learning videos (Wisada et al., 2019) as well as in making blogs as a medium of knowledge sharing (Fransisca et al., 2021). Agricultural development in specific areas has been analyzed, highlighting the importance of technology-based agriculture, digital information, and marketing of agricultural products, as well as the role of government policies in supporting farmers and agriculture (Lawolo et al., 2022). Precision agriculture, autonomous vehicles, and neural network utilization in precision agriculture have been discussed, emphasizing the integration of information and technology in farm management for optimal and sustainable benefits (Efendi & Sagita, 2022). This reflects the positive impact of the development of information technology in providing a variety of information media that support various community activities.

b. Convolutional Neural Networks (CNN)

Convolutional Neural Networks (CNNs) are a fundamental component of deep learning, particularly in the field of computer vision. CNNs are designed to process and analyze multidimensional data, such as images, by utilizing convolution operators to extract informative features from local receptive fields at each layer (Hu et al., 2020). These networks typically consist of input, hidden, and output layers, and are widely recognized for their effectiveness in feature extraction and image classification due to their high efficiency (Mahdavi, 2022). CNNs are characterized by a hierarchical structure and strong feature extraction capabilities, making them particularly suitable for a wide range of visual tasks (Wang et al., 2020). CNN architectures typically involve a convolution layer, a subsampling layer, and a fully connected layer at the output, allowing local connection, weight sharing, and sub-sampling, which are important characteristics of this network (Guo & Wang, 2020). CNNs have been shown to outperform fully connected neural networks, as they have the ability to reconstruct the output of a fully connected network with a similar number of free parameters (Cheng & Cheng, 2022).

c. Python

Python is an advanced programming language that is often used in web application creation and software development (Abdillah, 2021). Based on its working principles, Python offers a syntax that is easy to learn and understand, while providing support for working across platforms and operating systems (Latifah &; Prasetyo, 2021). With its intuitive syntax, Python is applied in a variety of needs, from web development to data analysis, artificial intelligence,

and system programming (Marwan et al., 2022). Python is also used in software development for information systems (Ihsan et al., 2022) DAM Mobile Application (Gunawan et al., 2020). With its flexibility, Python allows use in a variety of software development contexts, making it one of the most versatile programming languages. Python programming language is widely used in various applications including rice quality detection (Altim et al., 2023), face mask detection (Sopian et al., 2023), facial recognition system (Susim & Darujati, 2021), and various other applications. Python was chosen for its rapid development, fast processing, and scalability (Apriandi & Zen, 2022). This programming language is also popular for data science and machine learning applications (Limanto et al., 2023) and used in web application development (Sabita et al., 2022). Python flexibility allows direct variable declarations without specifying data types (Fauzian & Rachman, 2022). This proves that Python's flexibility can be applied to various fields, as a programming language in overcoming technological challenges including information media technology.

d. Laboratory Learning

Laboratory learning is a learning method that prioritizes direct and practical experience as a way to understand and apply theoretical concepts. In this learning, students not only sit in class listening to teaching or reading texts, but are also actively involved in experiments or practicum activities in the laboratory. This allows them to observe firsthand the phenomenon being studied, test theories, and develop practical skills (J. Chen et al., 2020).

Laboratories are essential in disciplines such as science and technology, where conceptual understanding often requires practical demonstration. In the laboratory, students can conduct experiments, use special equipment, and apply scientific procedures to test hypotheses or solve problems. (Berutu). This hands-on approach allows students to engage in practical activities, conduct direct observations, and develop practical skills because laboratory learning can encourage the development of scientific methods and problem-solving skills among students (Sari et al., 2022). In addition, the use of the scientific method in laboratory experiments allows detailed data collection through various data collection procedures, such as pretest and posttest, to assess problem-solving abilities and learning gains (Nurhasanah, 2023). Learning in the laboratory also helps develop other important skills such as critical thinking, problem-solving, teamwork, and communication skills. Students learn to work in a structured and methodical manner, take accurate records, and report their findings clearly and objectively.

Collaboration in laboratory activities also allows students to learn to work in teams, share responsibility, and reward individual contributions in achieving common goals (Ridwan et al., 2023). Learning in the laboratory can improve students' problem-solving, interpersonal, and intrapersonal communication skills, which shows the importance of communication in finding solutions to given problems (Ridwan et al., 2023). In addition, laboratory utilization allows students to develop critical thinking, problem-solving, and communication skills (Kamza et al., 2021). Because, in the laboratory students can improve their ability to analyze information, evaluate evidence, and develop arguments supported by empirical data (Ristina et al., 2020). In addition, laboratory activities allow students to learn teamwork, share responsibility, and reward individual contributions in achieving common goals (Julifa et al., 2022). Thus, through the laboratory associated with its use in learning, it can be an effective solution to increase student motivation and curiosity so that they can connect the theory they learn in class with real-world applications, thereby increasing the relevance and effectiveness of the teaching and learning process.

C. Research Methods

This research method is the use of one of the digital technologies, namely CNN technology as a project-based information media with the topic of classifying coffee beans, using the

inquiry method. This research activity involved 20 students divided into groups, with the aim of determining the effectiveness of using CNN technology to classify coffee beans and determine the effectiveness of implementing project-based laboratory learning. The mindset of the implementation of this research is:

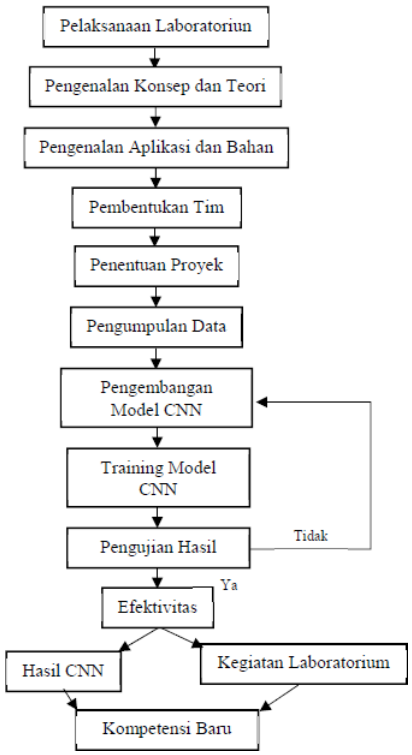
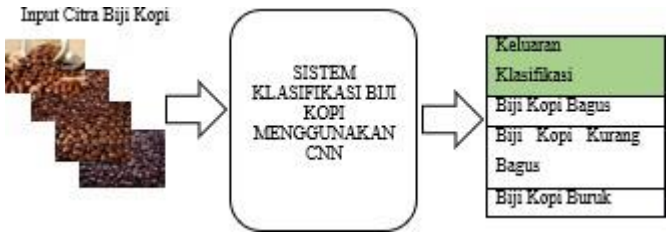
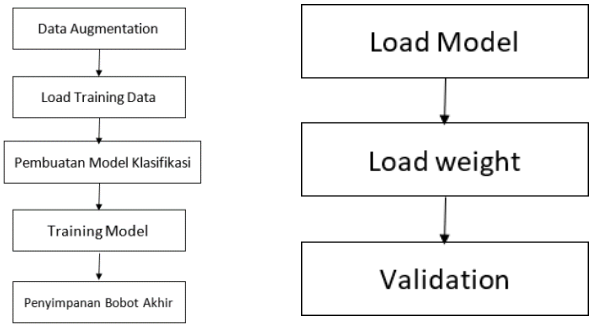


Figure 1. Research mindset

The implementation of the application of CNN for classifying coffee beans begins with a workflow of collecting data in the form of images or videos of coffee beans with different shapes and textures to be used as datasets. These images will be categorized based on the type and shape of the coffee beans, as well as their quality, be it good or bad. Images or videos taken through digital cameras will be used as a reference for the image dataset to be trained. The more data trained, the higher the learning accuracy can be achieved, which in turn will improve the accuracy and precision of the data in testing and validation. Before the learning process, a learning model will be created first. In the CNN method, the number of layers and tissues used is unpredictable from the start because it largely depends on the type of data entered to be trained, including the texture, color, and lighting of the captured object image. This training process needs to be repeated with various models to determine the most effective CNN model. In the testing phase, the system will first load a pre-trained model. This process involves using a pre-prepared weight file to further test the image of the coffee object to be validated. The accuracy of this validation process will also increase as the percentage of training that has been done increases



(a)



(b) (c)

Figure 2. (a). Coffee Bean Classification System Architecture, (b). Coffee bean classification training flow model, (c). The image test pipeline to validate.

D. Result

In this project, use Python Jupyter Notebook as a platform to run programs. Here is a look for importing the necessary libraries in the program:

```
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.preprocessing import image
from tensorflow.keras.optimizers import RMSprop
import tensorflow as tf
import matplotlib.pyplot as plt
import cv2
import os
import numpy as np
```

Figure 3 Snippet of the Import library used

```
img = image.load_img("basedata/train/kopi_biasa/3.PNG")

plt.imshow(img)

cv2.imread("basedata/train/kopi_biasa/3.PNG")

cv2.imread("basedata/train/kopi_biasa/3.PNG").shape
```

Figure 4. Snippet of command view for calling and reading image data

```
model = tf.keras.models.Sequential([tf.keras.layers.Conv2D(16,(3,3),activation = 'relu',input_shape=(200,200,3)),
                                    tf.keras.layers.MaxPool2D(2,2),
                                    #
                                    tf.keras.layers.Conv2D(32,(3,3),activation = 'relu'),
                                    tf.keras.layers.MaxPool2D(2,2),
                                    #
                                    tf.keras.layers.Conv2D(64,(3,3),activation = 'relu'),
                                    tf.keras.layers.MaxPool2D(2,2),
                                    #
                                    tf.keras.layers.Flatten(),
                                    #
                                    tf.keras.layers.Dense(512,activation = 'relu'),
                                    #
                                    tf.keras.layers.Dense(512,activation = 'sigmoid'),
                                   ])
```

Figure 5. Command view snippet for creating a Training model

```
model.compile(loss = 'binary_crossentropy',
              optimizer = RMSprop(ls=0.001),
              metrics = ['accuracy'])
```

```
model_fit = model.fit(train_dataset,
                      steps_per_epoch = 3,
                      epochs= 10,
                      validation_data= validation_dataset)
```

Figure 6. Compiled model view and commands for Epoch and Accuracy

a. Results of Coffee Bean Classification Effectiveness

The epoch used in the training parameters will determine the level of accuracy of image reading and detection of objects to be trained. The higher the epoch used will make the accuracy of object recognition high as well. This can be seen in the following picture.

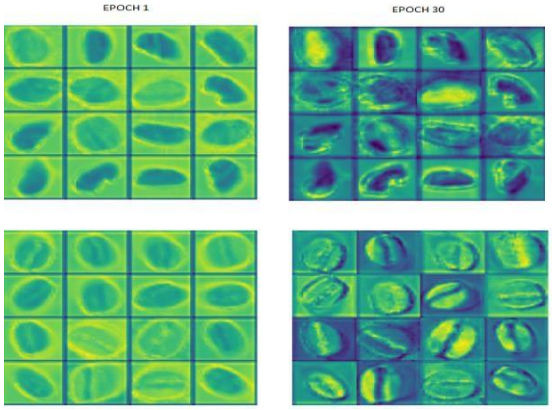


Figure 7, Results of Classification of Coffee Beans by Number of Epochs

```
1
Epoch 24/30
5/5 [==============================] - 2s 348ms/step - loss: 0.0024 - accuracy: 1.0000 - val_loss: 0.0344 - val_accuracy: 1.000
0
Epoch 25/30
5/5 [==============================] - 2s 362ms/step - loss: 3.3817e-04 - accuracy: 1.0000 - val_loss: 0.0543 - val_accuracy:
1.0000
Epoch 26/30
5/5 [==============================] - 2s 328ms/step - loss: 2.8656e-04 - accuracy: 1.0000 - val_loss: 0.1039 - val_accuracy:
0.9091
Epoch 27/30
5/5 [==============================] - 2s 375ms/step - loss: 6.5907e-05 - accuracy: 1.0000 - val_loss: 0.0831 - val_accuracy:
1.0000
Epoch 28/30
5/5 [==============================] - 2s 331ms/step - loss: 3.5524e-05 - accuracy: 1.0000 - val_loss: 0.1041 - val_accuracy:
0.9091
Epoch 29/30
5/5 [==============================] - 2s 323ms/step - loss: 3.4607e-05 - accuracy: 1.0000 - val_loss: 0.0773 - val_accuracy:
1.0000
Epoch 30/30
5/5 [==============================] - 2s 344ms/step - loss: 3.9313e-05 - accuracy: 1.0000 - val_loss: 0.0636 - val_accuracy:
1.0000
```

Figure 8. Display Running the program Number of Epochs and Accuracy

To classify coffee objects that have been trained and the classification model has been stored in the form of .h5 files. The model has been invoked and can be used to predict images of new coffee beans. This is done so that this program can classify new coffee bean images based on 2 classes, namely kopi_baik and bad coffee. To be able to classify coffee beans with many classes, it can be done by increasing the amount of data and classification of coffee image data so that the coffee class becomes increased as well. The resulting CNN method has an accuracy rate above 90%. This clearly proves CNN is more when compared to other neural network methods and proves that CNN can be used as a medium of information related to the classification of coffee beans

```
dir_path = "basedata/test"

for i in os.listdir(dir_path)
    img = image.load_img(dir_path+ '//'+ i, target_size=(200,200))
    plt.imshow(img)
    plt.show()

    X = imge.img_to_array(img)
    X = np.expand_dims(X,axis =0)
    images = np.vstack([X])
    val = model.predict(images)
    if val == 0:
        print ("Kopi Jelek")
    else:
        print ("Kopi Baik")
```

Figure 9. Command to call the tested coffee bean image data

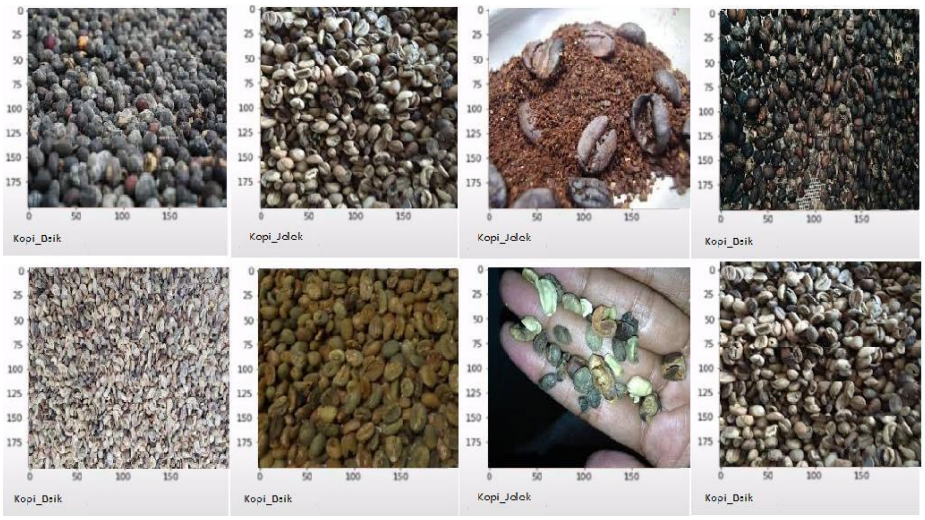


Figure 10. Classification Results Image of the coffee beans tested

b. Results of Laboratory Implementation Effectiveness

Table 1. *N-Gain Score Test Calculation Results*

Sum Student (person)	**20 people**
Practicum Class N_Gain Score (%)	
Average	63,4781
At least	31,10
Maximum	93,60

In table 1 above, based on the results of statistical calculations, it shows that the results of the N-Gain Score test *calculation obtained the average* N-Gain Score for the experimental class is 63.4%, so it is declared to be in the category of quite effective with the results of *a minimum N-Gain Score of* 31% and a maximum of 93.6%.

E. Discussion

This research obtained excellent results related to the use of *Convolutional Neural Networks* (CNN) for coffee bean classification projects. The use of CNN technology in coffee bean classification projects in computer laboratories shows a very high level of accuracy, reaching above 90%. This is a strong indicator that CNN, with its ability to process and analyze

visual data, is very effective in identifying and classifying different types of coffee beans based on their visual characteristics. This high accuracy shows that the developed CNN model is able to learn well from the training data and apply its knowledge to recognize patterns in new data with minimal error rates.

This suggests that CNN, with its ability to process and analyze visual data, is very effective in identifying and classifying different types of coffee beans based on their visual characteristics. The high accuracy shows that the developed CNN model can learn well from the training data and apply its knowledge to recognize patterns in new data with minimal errors. Furthermore, the application of CNN technology has been shown to improve accuracy through transfer learning, showing its positive impact on the level of accuracy obtained (Murinto, 2023). So, the utilization of CNN technology in the classification of coffee beans has proven to be very accurate and effective. This technology can play an important role in ensuring the quality and productivity of coffee production, meeting consumer demands, and improving overall process efficiency.

Furthermore, in the context of project-based learning in computer laboratories, the effectiveness of using information media utilizing CNN technology was recorded to be very satisfactory, with an effectiveness score of 93.60%. This shows that the integration of CNN technology in laboratory practice learning not only enriches students' learning experience from a technical perspective, but also enhances their conceptual understanding of advanced technology applications in the real world. Students not only learn about the basics of CNN and visual data processing, but also gain hands-on experience in applying these technologies to solve real problems. The use of technology, which has been shown to significantly impact students' conceptual understanding and procedural skills in a variety of topics, demonstrates the positive influence of technology on students' learning experience (Septaria, 2022).

The improved practical skills of computer labs are reflected in their ability to apply the concept of CNN into real projects, develop creative solutions to classification challenges, and produce high-performance models. This experience not only strengthens their technical skills in the field of programming and data analysis, but also develops critical skills such as problem-solving, analytical thinking, and teamwork. This provides strong evidence that the application of CNN as an information medium in the context of project-based laboratory learning is not only technically effective, but also very valuable in an educational context. This paves the way for further implementation of similar technologies in education, especially in disciplines that require a deep understanding of high-tech concepts.

F. Conclusion

Based on the results and discussion, the conclusions that can be drawn are:

Classifying coffee beans using images can be effectively done by training a model using images of coffee beans. This classification process involves separating coffee beans into two main categories, namely good quality and low quality coffee. In addition, the classification can also be extended to various other categories, such as medium quality coffee, depending on the image of the coffee beans used. This CNN method proved to be very effective, achieving accuracy rates above 90%, demonstrating its advantages over other neural network methods.The effectiveness of using information media that utilizes CNN technology on student learning outcomes is recorded to be very satisfying, with effectiveness reaching 93.60%. This shows that the integration of CNN technology in laboratory practice learning not only enriches students' learning experience from a technical perspective, but also enhances their conceptual understanding of advanced technology applications in the real world. This also proves that students are able to solve problems, think

critically and analytically and are able to work in teams.

G. Suggestion

The positive results of using information media using CNN can support recommendations for further implementation of similar technologies in education, society and industry programs, especially in disciplines related to AI and visual data processing.

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