Development of Human-Machine Interface IoT Learning Media Based on Android for Sorting Machines

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Abstract: This research seeks to create an Android app that serves as a Human Machine Interface (HMI) learning tool for sorting machines, which will be used in the interface and data communication course in the Industrial Electronics Engineering department at SMKN 1 Rejotangan. The method used is the Research and Development (R&D) model by Borg & Gall, simplified into five stages: analysis, planning, development, product validation, and testing. According to the research results, the analysis stage identified the need for learning media. The HMI design was developed during the planning stage, and during the development stage, the application was created using the Android platform. Product validation results by subject matter experts and design experts show excellent conformity. Product trials with students show that this HMI application is practical and helps students understand IoT concepts easily. In conclusion, this Android-based HMI application is helpful as a learning medium to enhance students' understanding of interfaces and data communication.

Abstrak: Penelitian ini bertujuan untuk mengembangkan media pembelajaran *Human Machine Interface* (HMI) berbasis Android untuk mesin sorting sebagai media pembelajaran dalam mata pelajaran antarmuka dan komunikasi data pada jurusan Teknik Elektronika Industri di SMKN 1 Rejotangan. Metode yang digunakan adalah *Research and Development* (R&D) model Borg & Gall yang disederhanakan menjadi lima tahap: analisis, perencanaan, pengembangan, validasi produk, dan uji coba. Hasil penelitian menunjukkan bahwa pada tahap analisis, kebutuhan media pembelajaran diidentifikasi sebagai sangat diperlukan. Pada tahap perencanaan, desain HMI disusun dan pada tahap pengembangan, aplikasi dibuat menggunakan *platform* Android. Hasil validasi produk oleh ahli materi dan ahli desain menunjukkan kesesuaian yang sangat baik. Uji coba produk pada siswa menunjukkan bahwa aplikasi HMI ini sangat praktis dan memudahkan siswa dalam memahami konsep IoT. Kesimpulannya, aplikasi HMI berbasis Android ini efektif sebagai media pembelajaran untuk meningkatkan pemahaman siswa terhadap antarmuka dan komunikasi data.

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A. Introduction

The development of technology has brought rapid changes to the world, especially in the industrial sector. Since the introduction of the 4.0 industrial revolution in Germany in 2011, many things in the industrial world have changed. Whereas computers were only used to control various industrial machine equipment in the past, they have now shifted towards a more efficient direction. We are in the era of Industry 4.0, where various advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), big data, robotics, and cyber systems are combined to create smarter and more connected production systems (Schwab, 2017). So that the production process in the industry can be carried out even from a distance, and product reports can also be monitored remotely. Not only that, but using sensors integrated with the internet also encourages using materials to become increasingly efficient. Moreover, monitoring can be done in real-time. Even in this case, if integrated with big data, it can create data logging that can record every result and issue, which can be used to improve production in the future. Even the discovery of 5G internet is further accelerating the advancement of Industry 4.0 and the Internet of Things globally.

Implementing the Internet of Things (IoT) in various industrial sectors has brought significant changes, including logistics delivery. Currently, consumers can monitor the status of their shipments down to specific locations, even seeing the position of the package sender in real-time. This increases transparency in the delivery process and provides a clearer map of where the goods are at each journey stage. With this technology, the efficiency and speed of delivery are better maintained, providing convenience for customers and enhancing the online shopping experience (Widiretno & Ratama, 2024). With this technology, delivery efficiency and speed are better maintained, providing convenience for customers and enhancing the online shopping experience (Widiretno & Ratama, 2024). In fact, not only in logistics, but even sorting machines are now widely using IoT. Not only in the logistics field, like sorting machines, but now many also use IoT. Sorting machines function as tools to separate items according to their needs. This machine is often used in manufacturing, food processing, agriculture, and many other industries where there is a need to automatically and efficiently sort goods or products. Implementing Internet of Things (IoT) technology in sorting machines enhances operational efficiency and enables real-time data monitoring and management, aiding in better decision-making (Pambudi & Wibowo, 2023). For example, this tool can be used in the agricultural industry to separate fruits according to their needs. This sorting machine can be used in the agricultural industry to distinguish between ripe and unripe fruits based on colour, size, and texture characteristics. This technology reduces the need for manual labour and ensures that only ripe fruits are sent to the market (Kumar & Singh, 2021). IoT-based sorting machines can also be used in manufacturing to differentiate components or goods based on specific quality or specifications. One example is the automotive industry, where sorting machines differentiate car parts based on size and material quality. This machine automatically inspects parts such as bolts, nuts, and other components to ensure that only parts meeting the allowed quality standards are installed. Sorting machines that use Internet of Things

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technology can detect defects or discrepancies more quickly and accurately than manual processes, increasing efficiency and reducing production errors (Mardiani et al., 2024). Zhang & Lee (2023) further explain that IoT technology is necessary to achieve intelligent sorting systems and network optimization in logistics. IoT's integration enhances productivity and sustainability by utilizing real-time data from sensors on machines, allowing companies to perform timely maintenance, reduce losses due to equipment damage, and improve the overall efficiency of the production system (Zaidi et al., 2024).

Human Machine Interface (HMI) is a system that enables interaction between humans and machines. HMI is a communication bridge allowing users to control and monitor machines or automated systems. HMI can be found in various applications, ranging from the manufacturing industry to consumer devices, and includes both hardware and software that facilitate this process. HMI provides visual displays and physical controls, allowing users to set system parameters, receive information about operational status, and interact directly with machines. This system is essential in the context of Industry 4.0, where HMI can connect with Internet of Things (IoT) technology to enhance efficiency and automate production processes (Wang et al., 2022). Through advanced HMI, users can also manipulate robotic functions, automated systems, and other smart home applications more intuitively and responsively, providing a better interaction experience between humans and machines (Qi et al., 2024).Through advanced HMI, users can also manipulate robotics functions, automated systems, and other smart home applications more intuitively and responsively, providing a better interaction experience between humans and machines (Qi et al., 2024).

Given the rapid development of the industrial world and its penetration into all sectors, the education sector must quickly adapt to remain relevant to the industry. The rapid development of the industrial world has penetrated all sectors, and the education sector must quickly adapt to remain relevant to the industry. Therefore, the curriculum is continuously and dynamically developed to keep up with the industrial world. In vocational education, all tools are made to be the same as those in the industry so that the students trained can enter the industrial world directly. The curriculum changes in the Industrial Electronics Engineering department include a new subject or element called interface and data communication. This element has several learning outcomes, such as applying Object Oriented Programming (OOP) software, applying interfaces, applying data communication, applying data logging, and utilizing the Internet of Things (IoT). In this case, students in the Electrical Engineering department must keep up with the times, where students must learn programming not only limited to microcontrollers but also connected to interfaces that end users will use. Not only that, but students are also required to utilize IoT in various applications. The Internet of Things (IoT) in electrical engineering education has great potential to enhance students' abilities to face increasingly advanced technological challenges. With the integration of IoT technology into the curriculum, students can learn through practical applications that are relevant and connected to the real world. For example, Küçük et al (2019) emphasize the importance of system design and IoT-based

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training in engineering education, as this prepares students with the skills needed in the ever-evolving industry (Küçük et al., 2019). Furthermore, Šimon & Gogolák (2024) demonstrate that the implementation of IoT-based mobile robot platforms in education provides students with practical experience in the design and development of engineering systems, which are vital skills in the Industry 4.0 era (Šimon & Gogolák, 2024). Thus, including these elements in the curriculum creates a learning environment that encourages exploration and innovation for students in the field of electrical engineering.

At SMKN 1 Rejotangan, no suitable trainer is available since this is a new element in the Industrial Electronics Engineering subject. However, microcontrollers and pneumatic PLC trainers can be adapted. Moreover, there is currently no interface that is compatible with the microcontroller programming that has been studied. Therefore, creating an appropriate interface for students to learn and understand the Internet of Things (IoT) and how it works is important. Research by Syamsu et al (2023) shows that the creation of IoT-based learning media, such as Arduino microcontroller trainers, can help students better and more practically understand IoT concepts. Additionally, it emphasizes the importance of innovative and integrated learning devices, which can support students in learning independently and enhance their understanding of technology (Fadhilah et al., 2023). With a well-designed interface, students can be more interactive and effective in learning, thus preparing them to face technical challenges in the future (Priyana, 2024). Many alternative options can be used for interface creation, whether based on Windows, Linux, Android, or iOS. It seems there is no text provided for translation. Please share the text you want me to translate; I will gladly help! In choosing software usage, it is important to consider the situation of students at SMKN 1 Rejotangan, most of whom use Android smartphones. This encourages the development of an interface for Android devices that suits most students. Thus, students can easily understand and use the interface because they are already familiar with the Android devices they own. Research by Khakim et al (2023) shows that introducing Internet of Things (IoT) technology and using commonly used devices such as smartphones can enhance student engagement and understanding of the material being taught. Furthermore, research by Santika et al (2022) revealed that applying technology that aligns with students' needs and preferences can provide a more efficient and effective system in learning. This highlights the importance of developing applications that can be accessed through devices commonly used by students, creating a more interactive and responsive learning environment that meets their needs (Sansurizal, 2018).

In application interface development, many application options exist, such as Android Studio, MIT App Inventor, Kodular, and so on.In the development of application interfaces, there are many application options to choose from, such as Android Studio, MIT App Inventor, Kodular, and so on. In this research, we used Kodular because Kodular is one of the web-based platforms that allows the creation of Android applications for free. Additionally, Kodular simplifies the arrangement of the logic of the created interface because users only need to arrange blocks (block-based programming) (Dimas et al., 2024). The sorting trainer for the chosen output is already available at the school, but this trainer

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needs to be modified to enable IoT access. The sorting trainer was chosen because almost all industries have an automatic sorting process. Therefore, in addition to learning about IoT, students also learn about the working principles of the sorting system available at the school. In developing the interface for HMI communication and the sorting trainer system, Google Firebase is used as the database. Google Firebase was chosen for its ability to record data in real-time, which is very important in applications requiring continuous status updates. Additionally, Firebase supports microcontroller programming, which facilitates integration with various platforms. One of the major advantages of using Firebase is that this platform provides free services with certain limitations, which is very beneficial for developing projects that do not require high costs (Setyawan, 2024).

From the three devices/platforms, a learning medium will be created for students to learn about the Internet of Things (IoT) through hands-on practice. Here, students are encouraged to practise programming on microcontrollers to connect with existing interfaces and available databases. With this hands-on practice, it is hoped that students will find it easier to understand and increase their interest in learning. Margot & Kettler (2019) research shows that a practice-based learning approach helps students understand concepts more deeply and enhances their learning engagement and motivation.From the above explanation, it can be concluded that the importance of education, especially vocational education, is to always adapt to the ever-growing and evolving needs of the industry. Graduates produced by vocational schools must possess knowledge that aligns with industry needs. This should encourage teachers in their limitations to continue developing teaching media that align with industry standards and are easy for students to use in implementation. In this case, at SMKN 1 Rejotangan, the Electrical Engineering department must catch up with IoT trainers. This can be applied by developing the existing trainers so that they can be accessed with IoT. In addition, the interface must be created based on the existing environmental conditions so that they feel comfortable and not unfamiliar with the new interface. Therefore, creating a valid and practical learning medium in the form of an Android-based IoT Human Machine Interface Application for Sorting Machines is deemed important.

B. Method

In this research, titled "Development of an Android-based IoT Human Machine Interface Application for Sorting Machines," the Research and Development (R&D) method using the Borg & Gall model is simplified into five stages: analysis, planning, development, product validation, and testing.

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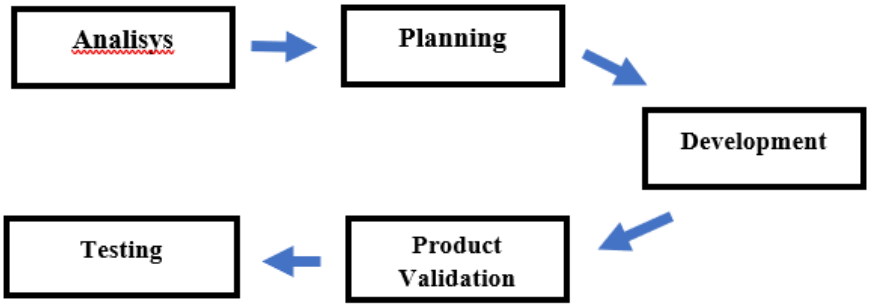

Figure 1. R&D Stages

At the analysis stage, the researcher seeks to identify any issues in the Industrial Electronics Engineering department at SMKN 1 Rejotangan and any needs that can be explored and realized to assist the teaching and learning process. Previous research by Dalu & Rohman (2019) highlighted the importance of initial analysis to identify communication constraints and digital simulation in the teaching process, which underpins the development of e-learning as one of the solutions to enhance the effectiveness of learning among vocational school students. Thus, this research adopts a similar approach, where the analysis phase focuses on identifying issues in the teaching and learning activities in the Industrial Electronics Engineering department and detecting needs that can be integrated into the application design. This supports improving the quality of the teaching and learning process and encourages the use of digital technology that aligns with the dynamics and characteristics of users in the SMKN 1 Rejotangan environment (Najoan et al., 2021).

In the planning stage, the researchers design the program flow to solve the problems identified in the analysis stage. This planning process includes defining software and hardware requirements and system modelling through flowcharts. This stage is important for ensuring that the developed solution addresses the previously identified problems (Al Faridzi, 2023). This approach provides a comprehensive overview of how the program flow will work, thereby minimizing errors during implementation and ensuring the solution aligns with the problems faced. At the solution development stage in the research, the researcher implements the workflow or concept map designed in the planning stage. However, in the discussed context, the development stage still does not include the validation process. According to Johnson & Schleyer (2003), validation in the development phase is critical, ensuring all system components function as intended. The validation process includes unit testing, integration testing, and system testing, where each testing stage focuses on detecting and correcting discrepancies between the implementation and the predetermined requirements.

In the product validation stage, researchers involve experts as validators to ensure that the developed product meets feasibility standards before it is directly tested. This validation process involves the distribution of questionnaires or other validation instruments to experts, such as content experts, media experts, and language experts (Seso et al., 2021). In the final stage, testing is a critical phase conducted by researchers after the product development is completed to ensure that the designed product meets the initial

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needs and specifications. At this stage, trials are conducted on samples that have been purposively or randomly selected to obtain valid data regarding the performance and effectiveness of the product. Product trials can involve data collection through questionnaires, observations, or tests. For example, Hananda et al (2023) reported that the developed product was tested on a predetermined sample, and the test results indicated that the product met the feasibility criteria for use by the target users.

The population in this study consists of 11th- and 12th-grade students in the industrial electronics engineering department. Moreover, the sample for this research consists of 6 students randomly selected from the Industrial Electronics Engineering department who have already studied the subjects of embedded system programming and data communication interfaces. The data collection technique in this research uses a questionnaire that will be given to teachers and students. So that the results can later be processed to conclude, the data analysis used in this study employs quantitative data analysis using descriptive statistics, which will later be used to process data from initial observations, expert validation, and product trials. The limitation in this study is that the product is only tested on a small group of 6 students from SMKN 1 Rejotangan.

C. Results and Discussion

Result

The results of this research were made according to the stages of the Research and Development (R&D) model by Borg & Gall, which were simplified into five stages starting from analysis, planning, development, product validation, and testing.

1. Analysis

In this analysis stage, a questionnaire containing the needs for a learning media for the subject or elements of interface and data communication was distributed to the teachers in the Industrial Electronics Engineering department at SMKN 1 Rejotangan. There were six people in total, and the questionnaire had 10 questions and a score range of 0-4 for each question. Following the distribution of the questionnaire, we obtained the results and presented them in Table 1.

Table 1. Results of the Questionnaire Analysis for Interface Learning and Data Communication

Respond	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Total
G1	4	4	4	4	4	3	4	4	4	3	38
G2	3	4	4	4	3	4	4	4	4	4	38
G3	4	4	3	4	4	4	4	3	4	3	37
G4	4	4	4	4	4	4	3	3	4	4	38
G5	3	4	4	4	3	4	4	4	4	4	38
G6	4	4	4	4	4	4	4	4	4	3	39
Total	22	24	23	24	22	23	23	22	24	21	228

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To determine the classification of the obtained amounts into specific categories, divide the data into five parts, as shown in the table below.

Table 2 Presents the Classification Table Used During the Analysis Stage

The Score Obtained	Category
193-240	Highly Needed
145-192	Required
97-144	Sufficiently Required
49-96	Not Required
0-48	Not Needed at All

The results obtained from Table 1 show that the maximum score achieved is 228, which falls into the essential category. At this point in the analysis, we can say that SMKN 1 Rejotangan needs learning materials for the interface and data communication topics to help students better understand IoT concepts.

2. Planning

At this stage, the researchers design the requirements to ensure that the product created meets the needs. In this research, a learning medium is needed for interface and data communication, especially for the learning outcomes of IoT utilisation. After observation, there is a PLC trainer in the form of a sorting trainer, which can be used as an output for programming that utilises IoT. So, an HMI that connects to a database and a microcontroller to control the sorting machine was chosen.

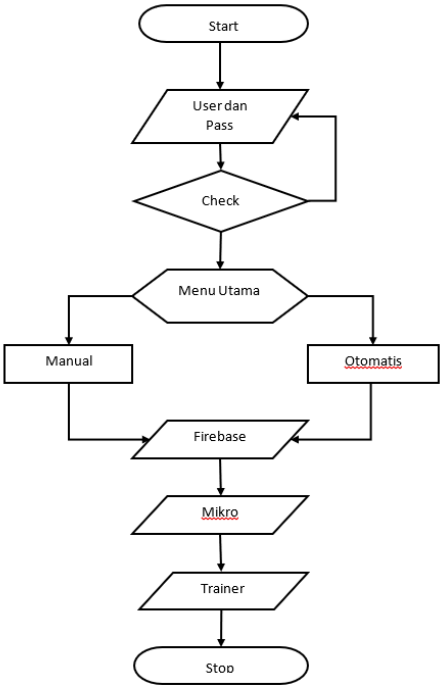

Figure 2. Program Flow Chart

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In the flowchart, we can see that in the user application, the user must enter a username and password. After that, it will be checked; if correct, they will enter the main menu. The main menu will have an option to enter manually or automatically. After that, the data from the manual or automatic will be sent to Firebase as a database. After that, the data from the database will be entered into the microcontroller and forwarded to the output for sorting.

3. Development

The application is starting to be created using the Android platform at this development stage. This Android platform was chosen because many students use Android-based smartphones. This choice allows students to become familiar with and efficiently operate the application. We created this application on the Kodular platform due to its ease of design and programming, which involves arranging the elements in block form.

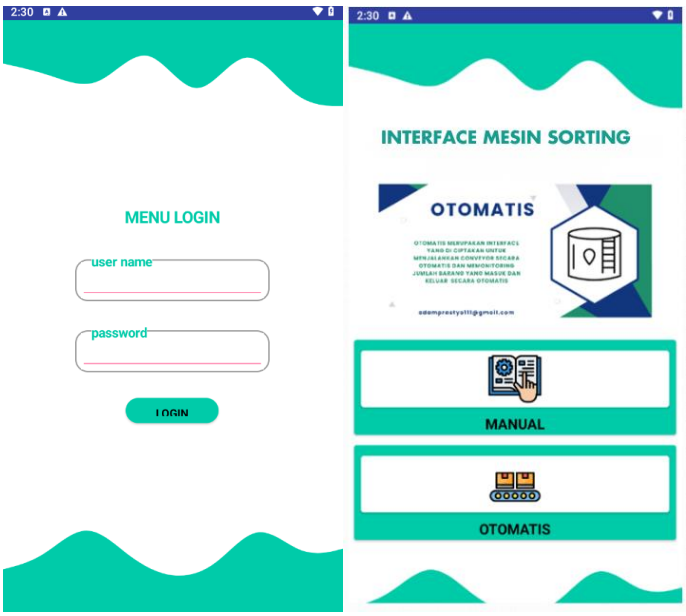

Figure 3. Menu, Login, and Main Menu

Main Menu: The initial screen will display a login menu, where the username and password must match. If they do, the system will automatically direct you to the main menu.

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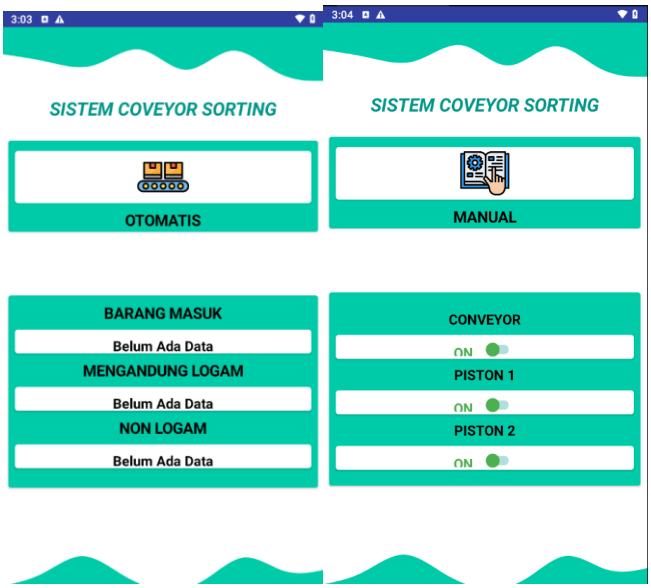

Figure 4. Automatic and Manual Menu

After entering the main menu, users can choose to control either automatically or manually; of course, the program on the microcontroller must also be adjusted. Next, it continues with the creation of a Firebase database. Moreover, the connection for the trainer's sorting has been created.

4. Product Validation

At this stage, the created HMI will first be validated by experts in content and design. The material will be validated by Dedy Subagyo, S.T., a senior teacher in the Industrial Electronics Engineering department at SMKN 1 Rejotangan, who also teaches interface and data communication. We will conduct the validation by providing a questionnaire with 10 questions.

Table 3. Score of the Expert Material Questionnaire Completion

Question	Score	Maximum Score
P1	4	4
P2	3	4
P3	4	4
P4	4	4
P5	3	4
P6	4	4
P7	4	4
P8	4	4
P9	3	4
P10	4	4
Total	37	40

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Once we obtain the results, we will classify them into five categories.

Table 4. Expert Validation Score Categories

The Score Obtained	Category
33-40	Very Suitable
25-32	Appropriate
17-24	Fairly Appropriate
9-16	Not Appropriate
0-8	Very Inappropriate

From the results in Table 3, we can see the obtained score of 37. Thus, we can conclude that the HMI application created is based on the existing interface and data communication material. The learning outcomes of IoT utilisation are significant. Next, the media will be validated by a media expert to assess the suitability of the design and function. Ekky Candra S.Pd, a computer and network engineering teacher at SMKN 1 Rejotangan, will validate this media design. He is the person who created and operates the SMKN 1 Rejotangan website, and he is also the developer of the Android application that has been used for exams at SMKN 1 Rejotangan. Table 5 displays the validity results.

Table 5. Maximum Ccore Results of the Media Expert (Design) Questionnaire Completion

Question	Score	Maksimum Score
P1	3	4
P2	4	4
P3	4	4
P4	3	4
P5	4	4
P6	4	4
P7	3	4
P8	4	4
P9	3	4
P10	3	4
Total	35	40

The table above shows a score of 35, indicating that the HMI application design is perfect. Both experts agreed that the research can proceed to the product testing phase.

5. Testing

The product trial was conducted only in a small group of 6 students from SMKN 1 Rejotangan, majoring in industrial electronics engineering, class XI. The students were randomly selected but had already studied embedded system programming, data interface, and communication.

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Table 6. Practicality Classification Results

The Score Obtained	Category
193-240	Very Practical
145-192	Practical
97-144	Fairly Practical
49-96	Impractical
0-48	Very impractical

Results are categorised into five categories: Very Impractical, Impractical, Fairly Practical, Practical, and Very Practical. This practicality reflects the ease of application and whether it helps students learn.

Table 7. The Results of the Questionnaire Filled Out by Students

Respondent	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	Total
S1	3	3	4	4	3	4	3	4	4	3	35
S2	4	3	4	4	4	4	4	4	3	4	38
S3	4	4	4	3	4	4	4	4	4	4	39
S4	4	3	4	4	4	4	3	4	3	4	37
S5	3	4	4	4	4	4	4	4	4	3	38
S6	4	4	4	4	4	4	4	4	3	4	39
Total	22	21	24	23	23	24	22	24	21	22	226

The students' completed questionnaire yielded a score of 226. Thus, it can be concluded that this HMI learning media application is efficient and facilitates students' learning process, especially regarding IoT. This means that the learning media makes it easier for students to learn about IoT.

Discussion

Based on the research results above, developing an Android-based IoT human-machine interface application for sorting machines is necessary in the electronics engineering department at SMKN 1 Rejotangan. This can be seen from the questionnaire results from the analysis stage filled out by teachers at SMKN 1 Rejotangan, which scored 228. This score is considered high and falls into the category of being very much needed. Because this interface and data communication learning includes IoT education, a learning medium is needed so students can directly practice IoT, making it easier to understand.

Next, based on the results of the planning and development, an Android-based application was created because most students at SMKN 1 Rejotangan primarily use Android smartphones. Next, the results from expert validation yielded a score of 37 for the material. This shows that the application created is based on the learning outcomes and ATP in the interface and data communication for vocational school students in the industrial electronics engineering department. In addition, the media or design validation results

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received a score of 35, indicating that the media design aspect is very much in line with the needs at SMKN 1 Rejotangan in the Industrial Electronics Engineering department.

Moreover, this application is easy to use, or, in other words, meets the practicality standards for use by students in the electronics department at SMKN 1 Rejotangan. The completion of a questionnaire proves this after being tested on students in the industrial electronics department at SMKN 1 Rejotangan, which resulted in a 226 score, indicating that the HMI application is efficient. From this, we can say that creating an Android-based IoT Human Machine Interface application for sorting machines can help students learn about interfaces and data communication, especially in reaching their IoT learning goals.

This reasoning is in line with previous research on the use of technology in learning media, such as the study by Aisyah et al (2024), which explains that the use of technology in Social Sciences learning can increase student interest and help them adapt to the constantly changing dynamics of information. Additionally, Hasriadi (2022) stated that using technology in creating learning media, particularly for Islamic education, can optimize the alignment between teaching materials and the characteristics of the media used. Ardiansyah & Nana (2020) emphasise that mobile learning, through Android-based applications, is a problem-solving process that can motivate students and improve their learning outcomes. This study explores how mobile applications can make learning more flexible and tailored to students' needs, which is expected to improve their overall academic performance (Ardiansyah & Nana, 2020).

Meanwhile, according to Maskuro (2022), using technology-based learning media is essential in achieving the teacher's learning objectives. Choosing media that aligns with students' characteristics can positively impact the quality of learning. In a changing learning environment, using applications that can be accessed through Android devices becomes important for adaptation. Meanwhile, according to research conducted by Fransisca et al (2023), it was also noted that by using smartphones in the learning process, students can be more actively engaged. Digital technology is increasingly evolving, making learning more efficient and effective. Using various applications, including mobile applications, to support learning can expand access to knowledge and increase students' interest in studying.

According to Rakhman (2022), using PLC (Programmable Logic Controller) and HMI-based AC motor control modules greatly enhances students' knowledge about industrial control and automation. By integrating this technology into the curriculum, students learn theory and relevant practices in the industrial world. Moreover, according to Qashlim et al (2023), the findings show that applying HMI systems in learning at technical schools can create a more interactive and engaging learning environment. The methodology that uses HMI facilitates students in understanding engineering concepts and developing their problem-solving skills. This shows that the presence of HMI can enhance students' interest and motivation in the learning process. Meanwhile, according to research by Darso et al (2023), training using IoT technology, such as ESP8266, for vocational high school students can enhance learning effectiveness. Students gain theoretical knowledge and

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practical skills relevant to the current industry needs by understanding how IoT devices work.

Rahmawati & Partana (2019) demonstrate that Android-based learning media incorporating IoT elements can enhance students' self-efficacy in understanding chemistry concepts, such as acids and bases. This approach shows that combining technology concepts with learning can attract students' interest and encourage them to be more actively engaged in the learning process (Ghofur, 2020). In the context of vocational education, the application of IoT is critical. A study by Kuswanto & Radiansah (2018) shows that Android-based learning media used in the subject of network operating systems can adapt the IoT approach to enhance the technical skills of 11th-grade students. The findings of this study highlight how important it is to have a curriculum that keeps up with new technology and show that creating reliable and useful learning tools can help make classroom teaching more effective.

The practical impact of this research is that it facilitates students' learning of IoT directly, as learning about it is very difficult when done through conventional teaching methods. In addition, the creation of this HMI application can be emulated by other schools with the same issues as those at SMKN 1 Rejotangan. In general, this research shows that technology-based learning media, such as IoT-based Android HMIS, which are valid and practical, can be used in vocational education so that students can practice directly, providing an enjoyable and impactful learning experience. In addition, this learning medium greatly facilitates the students' learning process, which can trigger pupils to increase their interest in learning.

One of the limitations in this research is related to the sample size, as the study was conducted with only six students from the industrial electronics engineering department. So, the results of this research may not be generalizable to all existing schools. Moreover, because the sample consists only of students from SMKN 1 Rejotangan, the needs may differ from those of other schools with different student capacities and competencies. Additionally, since the sample consists only of students from SMKN 1 Rejotangan, the needs may not be the same as those of other schools with different student capacities and competencies. Based on these limitations, further research is expected to be conducted with a larger sample size and not limited to just one school, so the results can be generalised to all existing schools. Based on the existing limitations, it is hoped that further research will be conducted with a larger sample size and not limited to just one school, so the results obtained can be generalised to all existing schools.

In addition, it is hoped that for future research on the HMI application, a feature will be added for students to communicate directly with teachers and include a job sheet in one unit within the application, making it easier for students to conduct practical work using just one application.

D. Conclusion

Based on the findings from the research that has been conducted, it can be concluded that the development of an Android-based Human Machine Interface (HMI) application for

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sorting machines in the Electronics Engineering Department of SMKN 1 Rejotangan can significantly contribute to students' understanding of learning materials, especially in the realm of the Internet of Things (IoT) and data communication. This application is deemed highly needed, effective, and practical for use by students and has met the validity criteria set by content and media design experts. These findings indicate that the application of Android-based technology has the potential to become a relevant learning tool and facilitate students in understanding concepts that tend to be difficult to grasp through conventional teaching methods.

This research shows that using technology-based applications like Android HMI can enhance the quality of learning in vocational education, especially in the Electronics Engineering department. The application allows students to practice directly with Internet of Things (IoT) devices, which enriches their learning experience and helps them develop skills that meet industry demands. In addition, this application also provides better learning flexibility, as students can access materials anytime and anywhere using their devices, namely Android smartphones.

Further research is recommended to involve a larger and more diverse sample, not limited to students at SMKN 1 Rejotangan, so that the research results can be generalised to other schools with different capacities and needs. Additionally, further research could develop direct communication features between students and teachers within the HMI application and include job sheets as an integral part of the application to facilitate practical work. These features are expected to enhance interactivity and ease the learning process.

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