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Development of IoT-Based and Project-Based Learning Human Machine Interface Learning Media to Improve Ability, Innovative Behavior, and Skill of Industrial 4.0 and Society 5.0 Students

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A R T I C L E I N F O

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A B S T R A C T

Background: Vocational high school students must learn new talents, innovative behaviors, and capacities to compete in the workforce in the industrial period 4.0 and society 5.0. This study aims to create a usable Trainer Kit based on the internet of things (MPHMI-B-IoT) for human-machine learning. **Purpose:** Development research is conducted using the ADDIE paradigm, which includes analysis, design, development, implementation, and evaluation processes to accomplish the purpose. **Methods:** The study involved 64 students and 8 teachers from vocational high schools in East Java, Indonesia, who were proficient in electrical power engineering. Simple random sampling was used to select the sample. Validation sheets, teacher-student response surveys, observation sheets on the application of the learning phases, ability assessment tools, individual inventive behavior observation sheets, and skill observation sheets were used to collect the data. Descriptive statistical methods and the paired sample t-test were used to assess the data. **Results:** Based on the validity, applicability, and efficacy of the results, it can be concluded that MPHMI-B-IoT is a viable technology. Before and after adopting a project-based learning paradigm that uses MPHMI-B-IoT as a Trainer Kit, there are noticeable improvements in the students' abilities, individual inventive behavior, and skills. Teachers can consider these results as they work to improve student proficiency in the 4.0 and 5.0 eras.

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1. Introduction

The Vocational High School (SMK) goal is to prepare students to enter the workforce as skilled workers (Aulbur, CJ, & Bigghe, 2016). Graduates are anticipated to possess a range of competencies in using high-order thinking skills (creative and innovative, critical thinking, collaboration, communication skill-4C). The current industrial era (IE) 4.0, characterized by the use of smart automation systems and changes in the digital direction, including the activity of connecting to the internet, calls for teachers to prepare students for entry into a society that is constantly undergoing an industrial revolution.

The era of society (ES) 5.0 has seen the emergence of new technologies, which will eventually have a greatly expanded version (Madsen, 2019). Diversity, decentralized problem resolution, resilience, environmental harmony, and sustainability are the five key components of ES 5.0 (Deguchi et al., 2020). Ideally, ES 5.0 is applied as a contemporary manufacturing change process, combining the different cognitive potential of workers with the technological know-how of robots to develop correct new behaviors in the workplace (George & George, 2020).

In the age of 5.0, products are developed based on consumer demands, adding value to production and ensuring that customers are happy to use products that emphasize human and machine connection (Deguchi et al., 2020).

Technology, people, virtual environments, actual circumstances, and virtual worlds can all be integrated to create a collaborative network (Serpa & Ferreira, 2018). The traits present in the modern workplace undoubtedly impact the shifting availability of different jobs (Ellitan & Anatan, 2020).

To satisfy the requirements of new forms of jobs, graduates must possess a wide range of new abilities. Active learning, creativity, critical thinking, negotiation, social management, and quality control are the ten abilities that are pertinent to IE 4.0 (World Economic Forum, 2015). Decision-making, collaboration, complicated issue-solving, and service orientation.

Since the capacity to employ soft skills in daily life is significantly more beneficial than simply acquiring hard abilities, 21st-century talents must be incorporated into education on a large scale (Erdoğan, 2019). Innovation is needed to fulfill the workforce's needs and the global market (Palazzeschi, Bucci, & Di Fabio, 2018). Psychological and technical innovation is a technology (Fetrati & Nielsen, 2018; Hammond et al., 2011). The development of innovative behavior and the use of technology are characteristics of technological innovation (Lukes & Stephan, 2017; Subramaniam, 2007) The innovation process includes parts of idea generation and implementation (Subramaniam, 2007). Self-innovation involves several steps, including problem identification, idea generation, idea fusion, network building, and idea realization. (Siregar, Suryana, & Senen, 2019; Subramaniam, 2007). Innovation in personal behavior is creating and applying new concepts (De Jong & Den Hartog, 2010).

Generating ideas for new products, services, or procedures to enter new markets, enhancing current work processes, and managing and merging existing concepts to solve challenges are all significant components of individual innovation behavior (De Jong & Den Hartog, 2010).

Organizational innovation is thought to be fundamentally influenced by the degree of individual innovative activity, both management and non-managerial (Wu, Parker, & De Jong, 2014).

This study aims to create a usable Trainer Kit based on the internet of things (MPHMI-B-IoT) for human-machine learning. Development research is conducted using the ADDIE paradigm, which includes analysis, design, development, implementation, and evaluation processes to accomplish the purpose. The primary literature did not create the media of human-machine learning. Thus, this work is based on a fresh idea. The study is important since it has significant theoretical and practical ramifications that will enhance students' knowledge and abilities at an extraordinary level. The earlier investigations did not cover this association.

Furthermore, this study's theoretical ramifications are brand-new to the field of knowledge. Similarly, the study contains noteworthy applications that are crucial to consider for enhancing pupils' learning through behavior and aptitude. Furthermore, the research's future directions make it important for experts to continue their work in this field.

2. Literature Review

For pupils to think critically, competitively, creatively, and innovatively, teachers and students must be able to adapt, grow, and enhance their competency in using digital technology-based learning approaches, including using Android (Bialik & Fadel, 2015). Vocational schools must create curricula, update practical facilities and equipment, and incorporate learning materials such as trainer kits based on HMI and IoT, and robots. Both educators and learners must be capable of critical thought, innovation, creativity, communication, cooperation, collaboration, and confidence (Achuthan et al., 2021).

Currently, vocational school teachers do not always include the 4Cs when planning and executing learning, and they do not often use project-based learning (PjBL), which tends to be more teacher-centered. This lowers learning quality because active learners retain information better than passive ones (Achuthan et al., 2021). Not all have produced Human Machine Interface Learning Media (MPHMI-B-IoT) as a Trainer Kit, and what happened in the Vocational Electricity Expertise Program in East Java, Indonesia, is still not ideal for delivering a PLC trainer kit. This can prove that SMK needs a PLC as a useful tool. The number of PLCs compared to the number of students using them is frequently disproportionate.

Many people in educational institutions (Heradio, de la Torre, & Dormido, 2016), especially in SMK, are unaware of virtual remote control (Vocational High School). Limited human resources and a relatively high price are the causes. The biggest percentage of media is in the form of PowerPoint, with 30.30% of vocational high school teachers creating or altering teaching aids and practicums (Basuki & Widodo, 2020).

The initial study's findings also demonstrate that a significant proportion of businesses have acknowledged the idea of Industry 4.0. At the same time, it is not yet clear how to implement it (Benešová et al., 2018). As a result, many businesses spend money educating their staff to operate automatic and contemporary machinery (Benešová & Tupa, 2017).

This demonstrates the academic community's involvement in developing worker competencies, sometimes known as the "education 4.0" notion (Benešová & Tupa, 2017). For students to be comfortable utilizing industrial equipment, the equipment must also adhere to industry standards.

The limited availability of IoT-based HMI (Human Machine Interface) learning media owned by SMK, about the demands of innovative learning and graduate competencies in EI 4.0 and the era of society 5.0, indicates that further research is still required on the "Development of IoT-Based Human Machine Interface Learning Media to Improve Ability, Individual Innovation Behavior, and Student Skills in IE 4.0 and ES 5.0."

The issue being investigated is whether there is a significant difference in students' abilities concerning the demands of EI 4.0 and the era of society 5.0 before and after being taught with the PjBL model using MPHMI-B-IoT in the form of a Trainer Kit; is there a significant difference in individual students' innovative behavior concerning these demands.

The PjBL model with the phases as shown in Figure 1 that was adapted from (George, 2007) must be used to support the use of MPBHPI-B-IoT in the form of a Trainer Kit because it is in line with the characteristics of industrial control and automation subjects and the competencies that students are expected to possess. Some of the processes include starting with the most important questions, designing projects, setting up a timetable, facilitating and tracking the progress of learning and projects, reviewing the results, and evaluating the experience.

2.1 PLC, HMI, and IoT

PLCs are a type of controller built on a microprocessor that employs programmable memory to store instructions for implementing logic, sequencing, timer, counter, and arithmetic operations to control machines and their operational procedures according to the programmer's designs. Industry-standard equipment is frequently used for control (Bolton, 2015), a computer built to handle machine operations in an industrial setting equipped with a special programming language and input/output (Wong & Siaw, 2015), and programmable devices work for control systems, from simple to sophisticated. Other devices like PAL, PID, and fuzzy control may also be utilized in conjunction with PLC (Patodiya & Singh, 2018).

A system for integrating human and machine technology is known as an HMI. The advancement of automation technologies has an impact on HMI development as well. Initially appearing as buttons and lights, it can now monitor and perform data analysis on a difficult or sophisticated process (Ardanza et al., 2019). In real-time, a technology system is visualized through the HMI feature. The design is simple to modify, making the physical task easier (Papcun, Kajáti, & Koziorek, 2018). The HMI system uses software to monitor electric motors. For the data to match the created design, the type must be PLC-compliant. When recognizing the data provided to the system controller's I/O port, the system on the HMI is real-time and live.

IoT is a concept that increases benefits by permanently connecting to the internet and remotely operating electrical devices (Tahaei et al., 2020). Each component employs wireless technology and is controlled online (Özdemir & Hekim, 2018). It possesses the capacity to transport data via a network without requiring human contact. Its application recognizes, monitors, and tracks things while setting off instantaneous and automatic events (Talari et al., 2017).

2.2 IoT-Based HMI Learning Media

The definition of media is anything that transmits information from its source to its recipient (Dewdney & Ride, 2006; Flew, 2018). Focus media combines technology with ideas and context (Dewdney & Ride, 2006). According to Smaldino et al. (2008), learning materials might come in tangible things, model objects, or manufactured objects in the form of a trainer kit. Trainer kits are frequently used in vocational schools, including tools, real or manufactured objects, and usage instructions in worksheets or learning modules.

The primary elements of the trainer kit-style IoT-based HMI learning materials for technology automation are PLC, HMI, and IoT devices. Manufacturers of existing automation products like Siemens (Aung & Thein, 2019), Omron (Sukir & Wardhana, 2019), Schneider (Akparibo, Appiah, & Fosu-Antwi, 2016), and Raspberry Pi employs HMI GUI and Python as their programming language (Khatri, Gupta, & Gupta, 2019), and other manufacturers use Arduino to develop and construct products (Abdullah & Putra, 2017) independently.

MPHMI-B-IoT was created as a training kit using tools and supplies that are common in the sector. Control using a PLC with an HMI and the Internet of Things, where each component uses wireless devices that can be controlled online. IoT for remote instruction and supervision. This medium can be used to operate a variety of devices, including electric motors used in manufacturing, parking lot management equipment, and more. It employs the project assignment method, the PjBL model, and the TPACK approach in its development. Additionally, the implementation supports problem-based learning.

3. Method

The study involved 64 students and 8 teachers from vocational high schools in East Java, Indonesia, who were proficient in electrical power engineering. Simple random sampling was used to select the sample. Validation sheets, teacher-student response surveys, observation sheets on the application of the learning phases, ability assessment tools, individual inventive behavior observation sheets, and skill observation sheets were used to collect the data. Descriptive statistical methods and the paired sample t-test were used to assess the data.

The ADDIE model is used in this development research. The fundamental building blocks of the ADDIE process are the analysis of students' backgrounds and needs, a collection of specific environmental designs that are efficient, effective, and pertinent, the requirements for resources and individual student learning arrangements, learning outcomes, formative tests, and summative tests (Branch & Dousay, 2015). Invoking the ADDIE model since it's still applicable: 1) It can adapt well to different situations, 2) It is highly flexible and efficient, and 3) It has a defined framework for creating instructional interventions, evaluating them, and improving them following the stages that are accessible.

3.1 MPHMI-B-IOT Development Stage

Analysis, Design, Development, Implementation, and Evaluation (ADDIE) stages are used in the development of MPHMI-B-IOT (Branch & Dousay, 2015).

Stages of analysis include examining pupils' starting points in terms of aptitude and expected competencies. The Electrical Power Installation Engineering Competence was taught to students (Komli TITL). The student's initial understanding and analytical skills related to electromagnetic control of electric motor controllers. Students are expected to understand, skill, and individual innovative behavior while creating PLC, HMI, and IoT-based electric motor control projects.

The design stage from the MPHMI-B-IoT Trainer Kit layer design is shown in Figure 1.

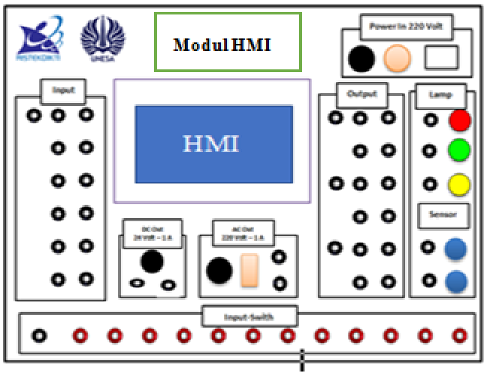

Figure 1. *Layer MPHMI*

The MPHMI-B-IoT was developed as a training kit using an acrylic frame material bundled in a box resembling a suitcase during the development stage.

A stratified random sample technique was used to decide the implementation stage involving 64 students and 8 teachers at Komli TITL SMK in East Java, Indonesia. Implementation to ascertain the viability of the created MPHMI-B-IoT. The viability of learning medium in terms of its efficacy, viability, and validity (Van den Akker et al., 2006).

The validity component of the MPHMI-B-IoT training kit's content validity is based on cutting-edge information and other media elements that are consistently related. By contrasting the content of the learning media with the material, one can determine the validity of the content. Validity is based on the findings of expert validation. According to experts and practitioners, learning media can be used in normal circumstances and by teachers and students (Van den Akker et al., 2006). The practical element demonstrates this. Applying learning and student and teacher reactions to the media determine practicality. Easy comprehension, clear explanations of instructions or information, appropriate appearance, motivation, interest, pique curiosity, and active inquiring, answering, and practicing are all indicators of reaction to MPHMI-B-IoT. The indicators for implementing the PjBL stages using MPHMI-B-IoT in a Trainer Kit begin with fundamental questions, project design, schedule creation, evaluation/monitoring of the students AND project progress, outcome assessment, and experience evaluation.

According to specialists with years of expertise, effectiveness demonstrates that the media works as expected when used (Van den Akker et al., 2006). The significance of talents, individual inventive behavior, and skills before and after being taught utilizing PjBL using the MPHMI-B-IoT created is used to determine effectiveness. The indicators are 1) students' aptitude for a 3-phase electric motor control project (P-PML-3P), which includes initiative, creativity, analytical thinking, responsibility, originality, autonomy, negotiation, quantitative aptitude, idea generation, and reasoning aptitudes; and 2) students' aptitude for academic performance. 2) The ability of students to create P-PML-3P, including active learning, critical thinking, programming, implementation programming, learning strategies, technology design, monitoring, leadership, concern for others, social influence, cooperation, complex problem-solving, social perspectives, systems analysis, social orientation, system evaluation, judgment and decision-making 3) Individual innovation behaviors that contribute to P-PML-3P, such as identifying new opportunities, utilizing novel goods or services, developing novel ideas, promoting novel concepts, resolving issues, and establishing new connections.

Before the implementation phase, expert validation was carried out to ascertain the reliability of the MPHMI-B-IoT, the reliability of teacher and student responses to questionnaires, the reliability of learning implementation observation sheets, and the reliability of assessment sheets (pretest-posttest) of students' abilities, skills, and individual innovation behavior. Validation denotes that the instrument measures under the predetermined design (Goodenough & Waite, 2012). Validity in quantitative research demonstrates that the measuring device can measure what it is intended to measure. Instruments need to be valid in addition to being reliable (Thatcher, 2010). Based on Aiken (1997), a value is considered invalid if it is less than 0.3 and valid if it is greater than 0.3. Before usage in the implementation stage, the assessment form or instrument is further validated for validity. On a Likert scale-based instrument, the Cronbach Alpha coefficient is used as a reliability indicator (Robinson, 2018). Low dependability (0.00-0.50), moderate (0.50-0.70), high (0.70-0.90), and extremely high (0.90-1.0) (Hinton, McMurray, & Brownlow, 2014).

Utilizing descriptive statistical methods, the information regarding the reliability and applicability of the learning media was examined. 5% significance level paired sample t-test to evaluate the significance of the difference between pretest and post-test findings. MPHMI-B-IoT eligibility indications are true, useful, and efficient (Van den Akker et al., 2006). Effective if the results of the paired sample t-test at the time of application show a significant difference between initial and final abilities, initial and final skills, and early and late individual inventions.

The evaluation step identifies and fixes any flaws that emerged during the research process as it continues to put together the report.

4. Findings and Discussion

4.1 MPHMI-B-IoT Development Result

A trainer kit for LookfrontMPHMI-B-IoT is available. By reading the data sent on the I/O port of the system controller, the system on the HMI operates online and in real-time. The com port, serial port, RS232 port, and USB port are all read by HMI. Based on existing systems or technology, HMI develops visuals.

The HMI design is simple to modify to accommodate the working environment's physical demands. The HMI system uses Cx-designer software to monitor a 3-phase electric motor. The employed PLC (type CP1E) and HMI (OMRON NB7W TW00B) are compatible, ensuring that the data obtained aligns with the design. The HMI's system operates online in real-time, reading data delivered to the system controller's I/O port. A com port, USB, or RS232 port are the controller ports that HDMI reads. HMI monitors can provide audible and/or visual alarm warnings in the event of abnormal circumstances in the manufacturing process since they can understand a process's flow. Each IoT component uses wireless technology and is governed by the internet.

4.2 MPHMI-B-IoT Validity

Aspect and result of MPHMI-BT validation in Figure 2, the average is 87.06 or 0.8706 in the valid category (Aiken, 1997). These results indicate that MPHMI-B-IoT is valid for use in learning with the PjBL model to make P-PML-3P.

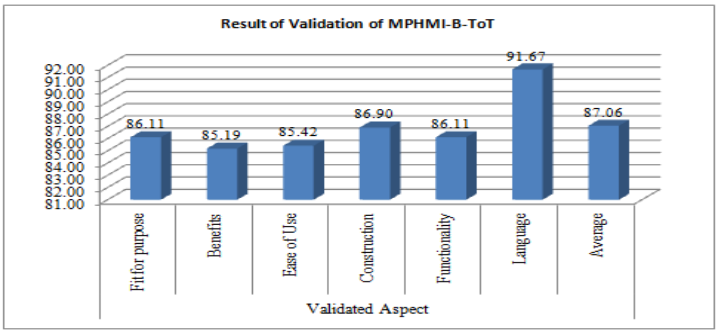

Figure 2. *Aspect and Result of MPHMI-B-IoT Validation*

4.3 Research Instrument Validity

A question about responses from teachers and students on surveys. Early understanding, information clarity, suitability, motivation, attractiveness, cultivating curiosity, active practicing, active asking, active answering, and the manifestation of these traits are all validated. an average of 0.8796 valid categories, or 87.96% (Aiken, 1997). Aspects of the learning goal fit, perception, core activities, closing activities, use of time, instrument display, and language implementation that were validated in the observation sheet with an average of 86.39% (0.8639) valid category P-PML-3P are validated in terms of the following: relevance of the question, concept truth, applicability of the variable ability, language, assessment rubric, format quality, hotspots for limitations, EI 4.0, and society 5.0. In general, 86.58% of categories are valid. (Aiken, 1997).

Validated aspects of the assessment tool/student skill observation sheet include idea truth, relevance to purpose, timing accuracy, language, acceptable grading rubric, form at quality, and skill constraints. Society 5.0 and EI 4.0. An average of 0.8810 valid categories. (Aiken, 1997). Aspects about purpose, idea truth, language, time allocation accuracy, format quality, proper grading rubric, life skills P21, EI 4.0, and society 5.0 are validated on the observation sheet/assessment of individual student innovative behavior. 88.10% on average (0.8810) valid category.

Cronbach's Alpha was used to determine instrument reliability, while results from expert validation were used to assess content validity. Table 1 provides a summary of the study instrument's validity and reliability.

Table 1

Validity and Reliability of Research Instrument

Instruments/Observation Sheet	Validity / Category	Alpha Cronbach/ Category
Ability	0.8796 / V	0.78 / Height
Skills	0.8810/V	0.74 / Height
Individual innovation behavior	0.8571 / V	0.71 / Height
Teacher/student response	0.8796 / V	0.76 / Height
Implementation of learning	0.8639 / V	0.77 / Height

Note: V= Valid

It appears that the reliability value for all instruments> 0.70 means reliable (Hinton et al., 2014) and valid because of V Aiken>0.3 (Aiken, 1997). Because the validity and reliability are high, the instrument meets the requirements for research at the implementation stage (Thatcher, 2010).

4.4 MPHMI-B-IoT Practicality

The average teacher response is 86.11, and the student response is 87.04. If combined, the average is 86.58 in the very high category (Suharsimi, 2010). The results are displayed in Figure 3.

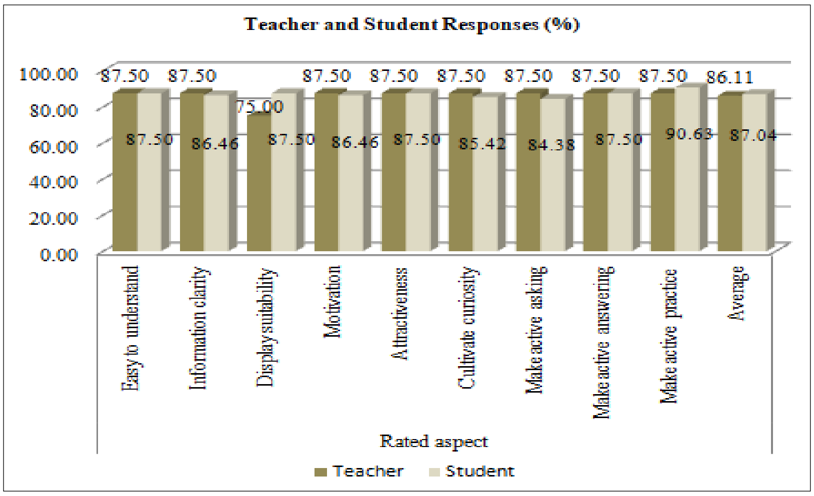

Figure 3. *Teacher and Student Response to MPHMI-B-IoT*

The implementation of learning is based on the observations made by two observers on the implementation of PjBL learning phases using MPHMI-B-IoT. Aspects of implementing PjBL learning using MPHMI-B-IoT in Figure 4 are an average of 83.38% in the very high category (Suharsimi, 2010).

Because the teacher/student response and the implementation of learning are in the very high category, the resulting MPHMI-B-IoT is very practical (Van den Akker et al., 2006).

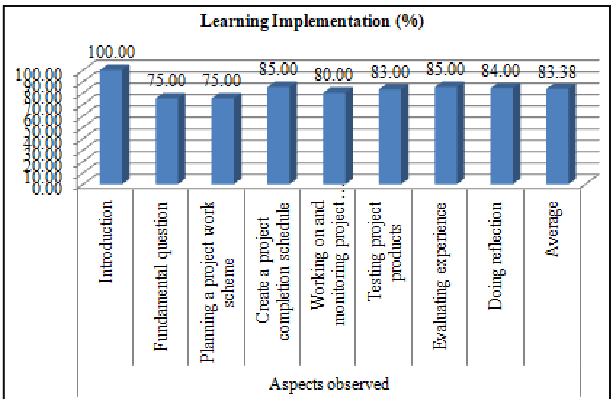

Figure 4. *Implementation of Learning*

4.5 Ability, Individual Innovation Behavior, and Student Skill

The topics of the 3-phase electric motor control project (P-PML-3P) include a variety of projects for the production process or system applications in industry, such as starting current control projects, reversing rotation direction, several rotating motors sequentially, several rotating motors alternately, rotating constant, rotating and stopping automatically, using the MPHMI-B-IoT Trainer Kit.

At the time of the post-test or final ability, the descriptive statistic of initial ability grew from 42,687 at the mean pretest to 78,672. The average score for the early individual's inventive conduct at the pretest time grew to 79,844 during the post-test. When the post-test or final skills were administered, the initial skills at the pretest mean of 43,687 improved to 80,344 (Table 2).

Table 2

Descriptive Statistic of Student Ability, Individual Innovative Behavior and Skill

Statistic	Initial Ability	Final Ability	Initial Individual Innovative Behavior	Final Individual Innovative Behavior	Initial Skill	Final Skill
Mean	42,687	78.672	41,687	79,844	43,687	80,344
Median	44,000	80,000	43,000	81,000	45,000	82,000
Variance	77,615	44,859	77,615	41,943	77,615	52,610
SD	8.809	6.697	8.810	6.476	8.809	7.253
Min.	15,000	63,000	14.00	67.00	16,000	59,000
Max.	59,000	94,000	58.00	95.00	60,000	96,000
Range	44,000	31,000	44.00	28.00	44,000	37,000

The results of the normality test using Kolmogorov, Smirnova, and Shapiro-Wilk are summarized as follows: initial ability is between 0.086 and 0.058; final ability is between 0.200 and 0.586; initial individual innovative behavior is between 0.086 and 0.058; final individual innovative behavior is between 0.072 and 0.520; initial skills are between 0.086 and 0.058; final skills are between 0.065 and 0.190. Everything with a sig. > 0.05 denotes a normal distribution of the data (Hinton et al., 2014). Test results for ability value sig. 0.216, individual inventive behavior 0.245, and skills 0.077 showed homogeneity of variations. The data variance is homogeneous, as seen by the sig value, all > sig 0.05 (Van den Akker et al., 2006). The mean difference test is used to determine whether the distribution is normal and homogenous, and the findings are shown in Table 3.

Table 3

Paired Sample T-Test Summary

	mean	t	df	Sig. (2-tailed)
Ability Pretest-Posttest	-3,598	-54,920	63	.000
Pretest- Posttest Individual innovative behavior	-3.665	-55.889	63	.000
Pretest- Posttest skill	-3,815	-41,983	63	.000

Pretest-Posttest Student Ability Scores of Sig. 0.000, indicating a significant difference between the students' initial and final abilities; Pretest-Posttest Student Individual Innovative Behavior Scores of Sig. 0.000, indicating a significant difference between the students' early and late individual innovative behavior; Pretest-Posttest Student Skill Scores of Sig. 0.000, indicating a significant difference between the students' initial and final skills (Hinton et al., 2014). These findings suggest that teaching with the PjBL paradigm while utilizing MPHMI-B-IOT as a Trainer Kit is successful or that there are notable differences in starting ability, individual inventive behavior, and students' abilities to make P-PML-3P before and after instruction.

The community must possess data literacy, technological and human literacy skills, and be able to follow the EI 4.0 workflow alongside ES 5.0, i.e., technology is part of humanity (Ellitan & Anatan, 2020). This is because the aspects or variables studied are based on the skill needs of EI 4.0, ES 5.0, P21 learning, and the demand for EI 4.0. This means that MPHMI-B-IoT in the form of a Trainer Kit can enhance students' capacities, inventive behavior, and skills in dealing with EI 4.0 and ES 5.0 as a result of development implemented in learning with the PjBL paradigm.

The following pertinent papers lend weight to the study's findings.

The use of IoT is very suitable for use in PLC and pneumatic practicum, remote laboratory, and makes students more skilled in dealing with EI 4.0 (Kustija, Hakim, & Hasbullah, 2020); Trainer Kit IoT can be used formally in industrial automation practices related to EI 4.0 (Somantri et al., 2019); the Krainer Kit HMI learning media for industrial automation techniques has received positive feedback from students and is valid according to experts including its performance (Karahasanović & Culén, 2022), but its effectiveness has not been tested (Maryadi et al., 2021);

IoT-based interaction systems as a support for successful education improve student learning outcomes (Gómez et al., 2013); the application of IoT-based learning media effectively improves learning outcomes (Nurhayati, Syam, & Yahya, 2022; Sulisworo et al., 2022)

5. Conclusion

In terms of validity, applicability, and effectiveness, MPHMI-B-manufactured IoT Trainer Kit is appropriate for use in project-based learning on 3-phase electric motor control material. Before and after being taught using the PjBL model employing MPHMI-B-IoT in the form of a Trainer Kit, there are noticeable differences in students' initial talents, individual inventive behavior, and ability to create 3-phase electric motor control projects. Students' aptitude, unique, innovative behavior, and skill in EI 4.0 and ES 5.0 can all be improved by teaching with the PjBL model employing MPHMI-B-IoT as a Trainer Kit. This research has implications for leading innovation and boosting student performance in EI 4.0 and ES 5.0 regarding ability, individual inventive behavior, and competence.

6. Implications

Because the development of this study had a substantial impact on the literature, the study has important theoretical implications. Although individual inventive behavior was undoubtedly examined concerning students' IoT skills in past studies, this study focused on IoT-based human machine-learning media. This study's progress added much knowledge to the corpus of literature in this area. The idea that this work has strengthened is innovative, and upcoming researchers need to learn about Trainer Kits to further their theoretical grasp. The theoretical ramifications of this study, which are outstanding for future understanding, have also added to the IoT literature. The study's practical applications are also noteworthy because its goal was to help students use new ideas to behave better and succeed at the required level. The study has repercussions for educators who are crucial to the kids' success. The Trainer Kit that this study designed is suitable for the IoT, which makes the positive usage of IoT in this study unique. This study has a good impact on the potential for improving the behavior performance of students throughout their learning, which is in line with the advancement of society 5.0 and new learning methodologies. This study has demonstrated that utilizing technology to assist learning and performance improvements for students is essential.

7. Future Directions

This study aims to create a usable Trainer Kit based on the internet of things (MPHMI-B-IoT) for human-machine learning. Development research is conducted using the ADDIE paradigm, which includes analysis, design, development, implementation, and evaluation processes to accomplish the purpose. Future studies are necessary to ascertain how artificial intelligence affects human-machine learning and the development of student skills. Furthermore, although the data used for this study were cross-sectional, subsequent research may validate its conclusions using longitudinal data. Finally, future studies should concentrate on how innovation adoption affects long-lasting behavioral changes in students' approaches to learning.

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