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Research Article

Improving AI Literacy Competence Among European Students: Implementation Recommendations for Indonesian Student)

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Abstract: This study aims to comprehensively examine the influence of the Problem-Based Learning (PBL) model integrated with the Internet of Things (IoT) on enhancing students' problem-solving abilities in physics education. The integration of IoT into PBL is seen as a progressive approach to address the growing demand for innovative instructional strategies that promote higher-order thinking skills. A quantitative approach was adopted, utilizing a quasi-experimental design with a pretest-posttest nonequivalent control group format to assess the effectiveness of the intervention. The participants were 25 undergraduate physics students from the University of West Sulawesi, selected through saturated sampling due to the limited population size. To evaluate students' problem-solving skills, data were collected using structured written tests designed around five key indicators: understanding the problem, describing the problem, planning the solution, executing the solution, and evaluating the results. Prior to hypothesis testing, normality of the data was assessed using the Kolmogorov-Smirnov test, followed by paired sample t-tests with IBM SPSS Statistics 23 to determine the significance of differences in pretest and posttest scores. The findings revealed a statistically significant improvement in students' problem-solving skills following the implementation of the IoT-based PBL model, with results showing significance at the 5% level and gain scores classified as effective. These outcomes demonstrate the potential of the PBL-IoT integration to foster critical thinking and improve educational quality. Therefore, the implementation of this instructional model is recommended for physics educators seeking to enhance student engagement, problem-solving proficiency, and learning outcomes through the integration of emerging technologies.

Keywords: AI literacy, collaboration, education, learning innovation, technology.

1. INTRODUCTION

The most important aspect of human life is one of them in the form of the acquisition of Education, because every individual has the right to develop himself through the world of Education. Based on the Law of the National Education System No. 20 of 2003 Chapter III Article 4 Point 5, it is stated that the purpose of the implementation of Education is to improve the habit or culture of reading, writing, and arithmetic for the entire community. Therefore, Daryanes et. al stated that efforts to develop a literacy culture need to be carried out through formal and non-formal education. The process of acquiring education includes the acquisition of knowledge, skill development, and behavior change from ignorant to knowing. As stated by Muhajang & Pangestika 2018, learning and teaching are important elements in Education, especially in the Education environment, namely schools. Education aims to humanize humans by actualizing all their abilities to be useful in social life.

We often hear the term literacy in the world of Education. According to the etymological, the term literacy comes from the Latin language "Literatus" which means a person who learns. With the ever-changing development of the times, the definition of literacy has always changed according to the challenges of the times.

Writing et. AL 2022 states that literacy is a skill in processing words, numbers, and information obtained through reading and writing activities. Purab and Purwono (2022) stated that literacy is also knowledge that refers to a set of abilities and skills in reading, writing, speaking, arithmetic, and solving problems. Literacy is not just about reading and writing, it includes the ability to think critically in utilizing various sources of knowledge, both

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print, visual, and digital (Rohim & Rahmawati, 2020). Hardiyanti (2022) stated that reading is considered an activity in daily life. According to Abidin, Mulyadi, and Yunansyah (2017:165), In the concept of literacy, reading is interpreted as an effort to understand, use, reflect, and involve oneself in various types of texts to achieve one goal.

The concept of literacy, which was previously only understood as the ability to read and write, has now developed rapidly. The definition of literacy encompasses a wide range of aspects, including science, numeracy, digital, media, school, and visual literacy, among many others. UNESCO's "The United Nations Educational, Scientific, and Cultural Organization" defines literacy as a set of functional skills, specifically reading and writing, regardless of the context and individual to which it belongs.

The latest technological advances require individuals to be not only proficient in reading and writing, but also literate in artificial intelligence (AI). Artificial intelligence (AI) is the application or instruction of computer programming to perform tasks that humans consider intelligent, or the study of how to make computers perform tasks that can currently be performed even better than humans. People's digital literacy not only includes the expertise to operate various information and communication technologies, but also the ability to communicate and understand various information presented by these technologies actively. AI literacy also includes an understanding of ethics and safety in the development and application of AI technology.

Artificial intelligence (AI) has been significantly integrated into modern life, supporting various sectors such as industry, business, healthcare and government. The rapid advancement of technology, information and computers has encouraged the development of AI, so now AI plays a crucial role in shaping the latest issues in the field of information technology, allowing computers to carry out tasks like humans. Understanding AI or AI literacy is becoming very important in the context of social life in the digital age. AI literacy leads students to understand the working mechanisms and wise use of AI.

Data from the Ministry of Education and Culture (Kemendikbud, 2021), states that the literacy of Indonesian students is still below average. The results of the 2019 Program for International Student Assessment (PISA) survey show that Indonesia is a country with a low literacy level. This shows that the reading interest of the Indonesian people is very low. Indonesia is among the 10 lowest countries in terms of literacy, as evidenced by data showing that Indonesia is ranked 62nd out of 70 countries.

Similar data is also provided by UNESCO, which shows that the reading interest of the Indonesian people is very low, only around 0.001%, which means that out of 1000 people, only 1 likes to read.

In 2022, research such as the Community Literacy Development Index (IPLM) and the Reading Interest Level (TGM) showed that Indonesia experienced an increase in literacy and reading penchant. Despite the progress, the literacy level of the Indonesian people is relatively low. Therefore, a more intensive strategy is needed to increase Indonesia's literacy and reading interest.

Indonesia not only has a low literacy rate, but also has low AI literacy as well. Previous research has used questionnaires to measure respondents' perception and level of understanding of various aspects of artificial intelligence (AI). This questionnaire measures four main aspects, namely awareness, use, evaluation, and ethics. The results show that there are some respondents who are not fully aware of how AI technology benefits them. Based on the problems in this study, we can see that AI literacy in Indonesia is relatively low and requires an effective strategy to improve it.

The education system in Europe, especially in France, Germany, and the Netherlands, is more advanced and sophisticated than in Indonesia, including in terms of innovation. This difference is also reflected in the level of artificial intelligence (AI) literacy among students. To improve AI literacy, universities in Europe are implementing a range of cooperative policies, including: a holistic approach that integrates the technical and ethical aspects of AI into the curriculum; gradual interventions that accommodate diverse student backgrounds; multi-stakeholder collaboration (government, industry, and society); impact-based evaluation on students' skills and work readiness; as well as integration with the national digital strategy. With this streamlined approach, European universities are trying to produce graduates who are ready to face the era of AI-based economy and society.

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2. LITERATURE REVIEW

Research in an article entitled Evaluation of Artificial Intelligence Literacy states that the definition of AI literacy has been put forward by various researchers. Of the 18 articles reviewed, about 12 of them define AI literacy based on the concept of literacy in general as well as various related aspects, such as evaluation, understanding, and awareness of AI, as well as various other questions. As AI grows more important, researchers are beginning to define AI literacy by referring to the concept of 'literacy' that has been applied in various disciplines (Long & Magerto, 2020). However, few studies provide a comprehensive explanation of how AI literacy can be conceptualized. To fill this gap, this study reviews the relevant literature as well as analyzes how scholars define "AI literacy", how AI literacy can be studied, and what are the ethical issues associated with it.

Previous research (Schneider & Sun, 2021; Luckin et al., 2022) show that the development of holistic artificial intelligence (AI) literacy—including infrastructure, curriculum, and multi-stakeholder collaboration—improves students' understanding and skills, and that personalized AI learning increases their engagement and learning achievement.

Previous research has shown that although the use of artificial intelligence (AI) is becoming more widespread, adoption across the field of higher education is not automatic and fast (Yu, 2020). Projections show that AI and automation have the potential to replace 400-800 million jobs by 2030 (Bughin et al., 2017; Smithies, 2017), but simultaneously it is expected to create 555-890 million new jobs (Hutson et al., 2022). Therefore, higher education is obliged to prepare students for these changes by developing competencies that allow them to collaborate, rather than compete, with AI.

Previous research by Popenici and Kerr (2017) examined the impact of artificial intelligence on teaching and learning in higher education, emphasizing the importance of adapting to technological developments to shape the future of education. The integration of AI in education is considered a transformative force that is able to improve the quality of learning and prepare students to face a technology-based world.

Previous research has shown that a holistic approach can increase students' readiness to optimally utilize artificial intelligence (AI) to support learning and future career development. This is in line with the Davis (1989) Technology Acceptance Model (TAM) which reveals that the perception of ease of use and benefits of technology is a determining factor for users' readiness for new technologies (FECIRA & ABDULLAH, 2020).

The role of teachers in guiding the development of students' intelligence remains crucial, with artificial intelligence (AI) as a supporter (Boentolo et al., 2024). Collaboration between governments, educational institutions, industry, and AI experts is essential to building an integrated and interconnected education ecosystem.

This study adapts the European approach in developing artificial intelligence (AI) literacy competencies in Indonesia. This research strategy applies a holistic approach that integrates AI literacy into various aspects of Education, phased interventions tailored to learners' understanding, multi-stakeholder collaboration involving governments, educational institutions, industry, and society, and impact-based evaluations to ensure program effectiveness. The goal is to significantly increase AI literacy among learners and undergraduates, preparing them for the development of the digital age.

3. RESEARCH METHODS

This study uses a mixed research method with an exploratory approach, which includes literature studies and questionnaire surveys. The literature review analyzes journals, books, and research reports to identify concepts, theories, and findings related to artificial intelligence (AI) literacy, including its influencing factors and related policies in various countries.

The results of this analysis became the basis for the development of a questionnaire survey instrument that was disseminated to students to measure the level of AI literacy, the factors that influence it, and their attitudes towards the use of AI in the academic environment. The questionnaire uses likert scales and open-ended questions to obtain quantitative and qualitative data that are further integrated to produce a comprehensive understanding of students' AI literacy and its improvement strategies.

4. RESEARCH RESULTS

Result

A. Time and Place of Research

1. **Research Time**
   This research was carried out on April 14 - 23, 2025
2. **Place of Study:**
   The research site uses Google Form or what is called an online questionnaire. A questionnaire is a data collection tool in the form of a series of written questions.

B. Tools and Materials

Tool

The tools used in this study are:

1. Laptops or computers are used to access journals, write reports, and process questionnaire data.
3. This research utilizes internet-online databases (Google Scholar, ResearchGate, Springer, IEEE Xplore, and university digital libraries) for the collection of scientific references and artificial intelligence policies in Europe and Indonesia. 3. Interview data is processed using Microsoft Word or Google Docs for writing, as well as Excel or SPSS (as needed).
4. Voice Recorder, Otter.ai, or Notta, The process of recording and transcribing interviews is done through the app.
5. Zoom, Google Meet, or WhatsApp Call, Google Form to be used as a questionnaire to provide questions with respondents at Medan State University or at other universities in North Sumatra.
6. Notebook - A stationery to record important things after the respondent answers the questionnaire given.

Material

1. Scientific journals and reference books that discuss artificial intelligence (AI) literacy, AI education, and AI policy implementation in Europe and Indonesia.
2. Official documents from international organizations such as UNESCO, OECD, and the European Union, as well as Indonesian government policies regarding AI development.
3. Latest articles and news that explore the development of AI literacy in the world of education.
4. A questionnaire guide that includes a list of key questions for lecturers, students, and industry practitioners in relation to the application of AI literacy.
5. The results of questionnaire transcripts which are the main material in thematic analysis and comparison between education systems in Europe and Indonesia.

C. Data Collection Techniques

In this study, the data collection technique was carried out by questionnaire method in the form of a questionnaire distributed online using Google Form. This technique was chosen because it is efficient in reaching a large number of respondents and allows for faster and systematic data processing.

Types of Questionnaires

The questionnaire used in this study was structured with a combination of closed-ended and open-ended questions.

1. The closed-ended questions used a Likert scale with five levels of answers (Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree) to measure AI literacy levels, student understanding, and barriers faced in accessing AI technology.
2. Open-ended questions provide an opportunity for respondents to express their opinions regarding their experiences, expectations, and suggestions in improving AI literacy in college.

They respond

Respondents in this study were students from the State University of Medan (UNIMED) and the State Islamic University of North Sumatra (UINSU) who were selected through purposive sampling techniques. The selection of these two universities was based on the following considerations:

1. UNIMED as one of the state universities that has a technology and education-based study program, so it is representative in seeing the application of AI in learning.
2. UINSU as an Islamic-based university has also begun to adopt technology in its academic system, thus allowing for a more comprehensive analysis of students' perceptions of AI literacy in different contexts.

Respondents' criteria include:

1. Students who are actively studying at UNIMED and UINSU.
2. Have used AI-based technologies in learning, such as educational applications, AI chatbots, or online learning systems.
3. Data Collection Procedure

Questionnaire Creation – The researcher designed the questionnaire using a Google Form which consists of several sections:

1. Part 1: Respondents' identities (name, nim, program of study, and University).
2. Part 2: Student recommendations related to improving AI literacy.

Questionnaire Distribution – Google Form links are shared through student WhatsApp groups, as well as social media platforms that are widely used by UNIMED and UINSU students.

Filling out the questionnaire – Respondents are given 7–14 days to fill out the questionnaire.

Data Verification – Incoming data is checked to ensure the completeness and validity of the answers before further analysis.

4. Data Analysis

The data obtained will be analyzed quantitatively and qualitatively:

1. Quantitative data from the Likert scale will be processed using descriptive statistics to see trends and patterns of respondents' answers.
2. Qualitative data from open-ended questions will be categorized based on specific themes to better understand students' perspectives related to AI literacy.

With this technique, it is hoped that the research can provide an accurate picture of the level of AI literacy among students as well as recommendations that can be applied to improve their competence in facing the digital era.

D. Data Collection Techniques

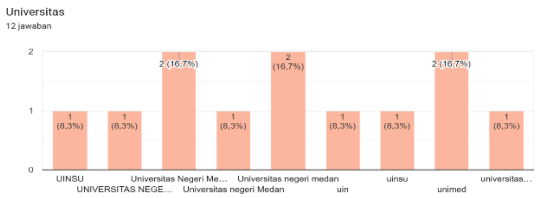
This research uses an online survey method through Google Form which is disseminated to students of the State University of Medan (UNIMED) and the State Islamic University of North Sumatra (UINSU). This method was chosen to reach respondents effectively and efficiently, as well as minimize costs and time compared to interview methods.

E. Data Analytics

This study analyzes survey data from the State University of Medan (UNIMED) and the State Islamic University of North Sumatra (UINSU) comparatively. The collected Google Form questionnaire data will be processed and visualized in the form of diagrams for easy interpretation.

Student questionnaire data from the State University of Medan and the State Islamic University of North Sumatra. The data collection is mainly about the institution and study programs taken.

Date 1 :



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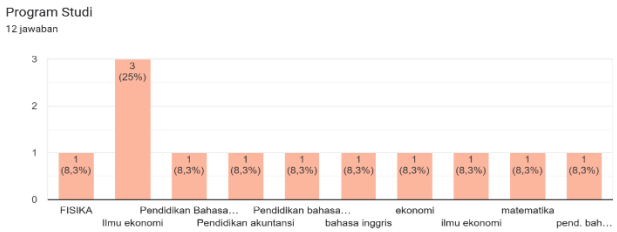
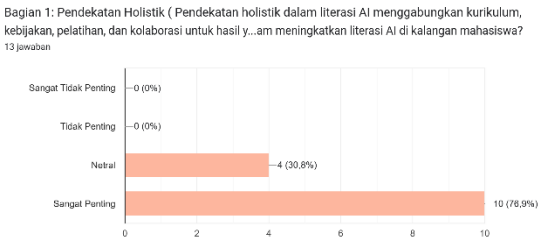
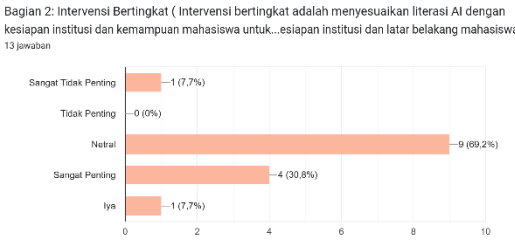


The questions in the questionnaire given to the respondents include;

How important do you think a holistic approach is in improving AI literacy among students?



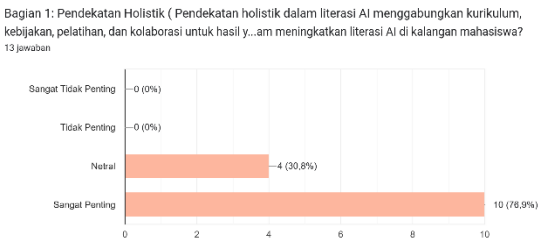
2. Is the AI literacy program at your university tailored to the institution's readiness level and student background?



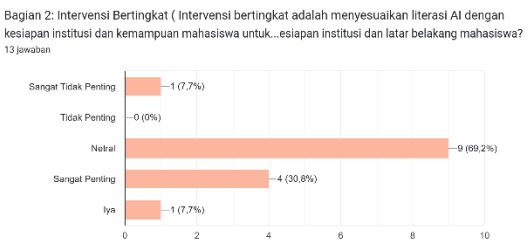
3. How do you think AI literacy programs can more effectively reach students from diverse backgrounds?

Answer:

1. There is still a lack of literacy with the increase. In order for AI literacy programs to be more effective in reaching students from diverse backgrounds, an inclusive approach needs to be implemented by tailoring the material according to the level of comprehension, from beginner to advanced, and using language that is easy to understand. The program must also be relevant to different fields of study so that students can see the benefits of AI in their disciplines, such as the application of AI in medicine, business, or the arts. Additionally, varied learning methods, such as interactive videos, case studies, workshops, and hands-on projects, will help accommodate a variety of learning styles. Accessibility is also an important factor in ensuring that the material is accessible to all students, including those with technological limitations or disabilities. Finally, collaboration with AI practitioners, lecturers, and senior students through mentorship programs can provide more personalized guidance and support deeper understanding.
2. Effective AI literacy programs for students with diverse backgrounds must be flexible and inclusive. Learning materials can be presented in a variety of formats, such as videos, texts, and hands-on practice, making them accessible to a variety of learning styles. In addition, a gradual curriculum needs to be implemented so that students with different basic understandings
3. Using programs that are tailored to the student's background
4. Prepare a more varied program
5. AI literacy programs for students with diverse backgrounds can be more effective with contextual and flexible materials, project-based approaches, inclusive accessibility, and specific needs-based training. The use of interactive digital platforms and personal mentoring can also increase their understanding and engagement.



4. Is the AI literacy program at your university tailored to the institution's readiness level and student background?



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5. DISCUSSION

The following is a table summarizing the results of the questionnaire based on data from respondents.

1. A holistic approach in AI literacy

Holistic artificial intelligence (AI) literacy, integrating curriculum, policies, training, and collaboration for comprehensive understanding, received strong support from survey respondents. As many as 75% of respondents consider this approach very important, and the rest (33.3%) are neutral; no one considers it unimportant. These findings underline the need for a comprehensive approach through technical aspects alone, including policies, ethics, and

collaboration between sectors to prepare students for an increasingly digital world of work. Universities, therefore, need to ensure that the AI curriculum covers these aspects.

2. Tiered interventions in AI literacy

The artificial intelligence (AI) literacy program is designed with a phased approach to accommodate the readiness of various institutions and the level of understanding of students. The survey results showed mixed responses: 66.7% of respondents thought it was neutral, 41.6% thought this approach was very important, and 8.3% thought it was less relevant. The high percentage of neutral responses identifies the importance of universities to enhance AI literacy programs with adaptive learning methods, for example through project-based learning, the provision of diverse digital learning resources, and an inclusive approach that accommodates students' diverse academic backgrounds.

3. Multi-stakeholder collaboration in AI literacy

The importance of multi-stakeholder collaboration (universities, industry, government, and civil society organizations) in improving artificial intelligence (AI) literacy was confirmed by the survey, although responses showed a gap between perception and implementation. Although 58.3% of respondents considered collaboration to be very important (there was no evidence that it was not important), a high level of neutrality of 60% indicated that the optimization of collaboration in the academic environment still needs to be improved. Therefore, universities need to strengthen cooperation with industry through AI internship and research programs, as well as encourage government participation in formulating more inclusive AI literacy policies.

4. The role of stakeholders in AI literacy

Respondents (75%) rated universities as the main actor in higher education's artificial intelligence (AI) literacy, while the role of industry (8.3%), and civil society (16.7%) is still limited. The government is not even considered a major stakeholder. These findings implicate the dominance of academic initiatives in AI literacy without significant roles from industry and government. For the development of AI literacy that is more comprehensive and relevant to the needs of the industry, strong synergy between universities, industry, and government is absolutely determined.

5. Impact-based evaluation in AI literacy

The evaluation of impact-oriented AI literacy programs aims to assess the effectiveness of the program comprehensively, not just based on the number of participants. The survey showed mixed perceptions, with 58.3% of respondents considering this evaluation very important, while the rest (41.7%) were neutral. These findings indicate the need to improve the evaluation method which is currently still considered less comprehensive. Universities need to develop a more measurable evaluation system, with a focus on tangible indicators such as improving students' skills in AI and its application of the natural nature of academic and industrial projects.

6. Integration of national digital strategies with AI literacy

The integration of artificial intelligence (AI) literacy into the national digital strategy aims at the development of a targeted and sustainable technology ecosystem. The survey showed mixed responses; 58.3% of respondents stated neutrality, while 41.7% considered this integration very important. These findings indicate a gap between national policies and the implementation of AI literacy in universities. Therefore, universities need to increase their

active role in aligning AI literacy programs with these policies to prepare students to face the dynamics in the digital era.

7. Recommendations for the integration of AI literacy strategies with national digital policies

Respondents suggested increasing AI literacy through the collaboration of government, industry, and academia; integration of AI in the Education curriculum; digital training for all levels of society; and more comprehensive AI regulations,. This underscores the reliance of AI literacy on strong policy support, so synergy between stakeholders is needed for effective and sustainable implementation.

8. The effectiveness of AI literacy programs for students with diverse backgrounds

In order to make artificial intelligence (AI) literacy for students from backgrounds more effective, respondents suggested the implementation of project-based flexible learning, interactive methods and personal guidance, as well as the presentation of materials in various formats (text, video, and hands-on practice). These findings show the need for an adaptive and inclusive AI literacy program, by ensuring the accessibility of learning materials for all students, regardless of differences in academic backgrounds.

6. CONCLUSIONS

This research shows that a holistic approach to artificial intelligence (AI) literacy is important for students, requiring integrated integration of curriculum, policies, and training. However, university preparation, industry and government involvement are still limited, as well as adequate evaluation, are challenges that need to be overcome. Universities play a central role in the development of AI literacy, but stronger synergy with industry and government is needed to adapt it to the needs of the job market and national digital policies. The application of flexible and inclusive learning methods will increase the effectiveness and sustainability of AI literacy programs.

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