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Navigating the tech-savvy generation; key considerations in developing of an artificial intelligence curriculum

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ABSTRACT

The progress in artificial intelligence (AI) technology has greatly changed various facets of society. This study aimed to explore aspects that need to be considered in developing AI curriculum for senior high schools in Indonesia. The qualitative approach employed in this study. The researchers utilized focus group discussions with schools' management and students at seven cities and group interviews with students at three cities. The results show that some schools want AI as an extracurricular activity, while others want it as a mandatory subject. School management and teachers aim for 2-3 competent AI instructors in each school. If no teachers are available, training will be provided to ICT, mathematics, or physics teachers for about a year to become AI educators. All participants agree on the importance of teaching students about AI applications and discussing ethical issues related to AI.

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1. INTRODUCTION

The advancement of artificial intelligence (AI) technology has significantly transformed numerous aspects of society. AI is now being utilized across various aspects of human life. AI's impact is evident in fields such as education, where it facilitates personalized learning experiences through adaptive learning platforms and virtual tutors. Gamification in education, powered by AI algorithms, not only enhances student engagement but also fosters critical thinking and problem-solving skills [1], [2]. In healthcare, AI-driven tools are revolutionizing patient care. The application and tools of AI is used to identify and prevent various diseases [3]–[5]. AI is also at the forefront of environmental conservation efforts. AI enhances and broadens our existing knowledge of climate change, playing a significant role in addressing the climate crisis effectively [6]–[8]. Moreover, AI-powered chatbots and virtual assistants have streamlined customer service in various industries, boosting productivity and enhancing customer engagement by improving communication between customers and customer service support, aligning with the core principles of digital transformation such as value creation, automation, interaction, transparency and control, improving efficiency, and enhancing user experiences [9]–[11].

In this rapidly changing landscape, cultivating AI literacy among younger generations is essential. It equips them with the skills needed to harness AI's potential, ensuring a technologically adept workforce capable of addressing the complex challenges of our time while driving innovation and progress. For that, to assist

learners in adapting to technological advancements, particularly in the development of AI, a curriculum for senior high schools is deemed necessary [12]–[14].

The development of AI curriculum for senior high schools plays a crucial role in providing a foundation for education that is relevant to the rapidly evolving technological era [12]. AI learning will offer new opportunities for personalized and adaptive learning experiences. AI education that keeps pace with technological advancements can undoubtedly assist students in developing skills that are pertinent to an increasingly interconnected and complex world [1], [15], [16].

Moreover, the development of AI curriculum also addresses the changing demands of the workforce. The current job market increasingly requires high-tech skills, and understanding AI becomes a significant added value. Through a well-designed AI curriculum, senior high schools can prepare students to enter a workforce driven by innovation and technology, giving them a competitive edge in the global job market [17].

While paragraphs above delineate the pervasive influence of AI across various sectors such as education, healthcare, and environmental conservation, it highlights the imperative of cultivating AI literacy among younger generations. Despite acknowledging the necessity of AI education, there remains a noticeable gap in the existing literature regarding the development and implementation of AI curriculum in high schools, particularly in the Indonesian context. While previous studies have explored the impact of AI on education and workforce demands, there is a dearth of research focusing specifically on the formulation of tailored AI curricula for senior high schools. Therefore, the researcher is conducting a study on the development of an AI curriculum for senior high schools in Indonesia to address these gaps.

This article is divided into three sections excluding introduction. In the method section, the researchers provide an overview of the research methods employed, detailing the participants involved, data collection methods, and data analysis procedures. In the results and discussion section, the researcher presents findings obtained from interviews and focus group discussions, elaborating on them with reference to previous research. In the conclusion section, the researcher summarizes the results and discussions and discusses how this research contributes and provides recommendations for future research.

2. METHOD

This study employs qualitative research methods, utilizing focus group discussions with school management and teachers, as well as students, to gather data. The researchers decided to employ qualitative research to explore participants ideas, opinion and beliefs ascribe to a social human problem [18]. The focus group discussions involve school principals, vice principals, IT teachers, science teachers, and non-science teachers, lasting approximately three hours with 10 to 12 participants. These discussions take place in 12 high schools across seven cities: Palembang, Depok, Bogor, Denpasar, Jembrana, Samarinda, and Yogyakarta. Researchers chose schools in thses citoes because many of them are already digital-friendly and have implemented technology in their teaching methods. Additionally, focus group discussions with 10 students are conducted for one hour each, spanning across eight schools in Palembang, Depok, Bogor, and Samarinda. Furthermore, group interviews with four students are conducted for about an hour in four schools located in Denpasar, Jembrana, and Yogyakarta. The students involved in the focus group discussions and group interviews were purposively selected, with one consideration being their prior use of AI technologies such as ChatGPT in their daily lives. These discussions and interviews aim to provide in-depth insights regarding the development of the AI curriculum and its associated aspects. It's important to note that this research represents the first year of a planned three-year study.

To enhance the quality of qualitative research and mitigate potential biases, researchers must consider triangulation. In qualitative research, triangulation refers to an approach that utilizes multiple sources of data, methods, or theories to evaluate, validate, or refine research findings. Several types of triangulation can be applied, including data triangulation, method triangulation, theory triangulation, and researcher triangulation [19], [20]. In this study, the researcher implemented data triangulation and researcher triangulation. Data triangulation was ensured by collecting data using more than one data collection method, namely through focus group discussions and interviews. Source data triangulation was ensured through interviews and focus group discussions with three community groups: students, teachers, and school management. Meanwhile, researcher triangulation was conducted by having one transcript analyzed by more than one person, followed by a focus group discussion among different researchers for analysis. This activity served as a form of moderation to ensure the evaluation team was thorough in providing final assessments.

In qualitative data analysis, various methods such as discourse analysis, narrative analysis, and thematic analysis can be employed. This study specifically utilizes the thematic analysis approach, as defined by Boyatzis [21] which involves encoding qualitative information. He describes thematic analysis as a method that enables researchers to perceive, interpret, and systematically observe qualitative information, transforming it into qualitative data for analysis purpose research chronological, including research design and research procedure [21]. The researchers utilized Boyatzis' thematic analysis method in analysing data gathered by

implementing three distinct stages in the process: addressing sampling and design considerations, creating themes and a coding system, and validating and applying the generated code.

3. RESULTS AND DISCUSSION

In this section, the researchers is discussing the results of this study. This study explored stakeholders' perspectives on AI curriculum development for senior high schools in Indonesia. Five broad themes emerged from the thematic analysis that has been conducted. The five themes are the curriculum implementation models, teacghers competences, content of AI curriculum, teaching strategies and assessments, and ethical issues on AI.

3.1. Curriculum implementation model

Based on the focus group discussions with teachers and school management we found that there are three possible models for implementing AI curriculum. The first model involves making AI a compulsory subject for high school students. According to teachers and school management supporting this model, the need for AI is unavoidable, and therefore, AI should be a mandatory subject in high schools. This is similar to the approach taken in the mid-2000s when the government made information and communication technology (ICT) a compulsory subject starting from junior high school. The following are quotess reflecting the viewpoints of teachers and school managements who support this model.

> *In my opinion AI education has become a necessity. Therefore, the subject of AI should rightfully exist and become a mandatory part of the curriculum for all students. This way, our students will have a good understanding of AI literacy, comprehend AI ethics, and be capable of producing AI products rather than just being users. (Head Teacher: Depok)*

> *AI should already be a compulsory subject for all students. In the past, when computer technology was advancing rapidly, ICT was introduced as a subject. Now, it's time for AI to be designated as a subject. (Teacher: Denpasar)*

The second model chosen by teachers and school management is to make AI a compulsory subject for class X and offer it as an elective subject for classes XI and XII. The main AI materials can be included in the ICT curriculum for class X, and it is mandatory for all students. However, in classes XI and XII, AI lessons can be offered as an elective subject for interested students. This model is selected considering two factors. First, the knowledge related to AI is deemed essential for students, especially in the context of using AI in everyday life, AI literacy, and ethics related to AI. Besides being AI users, students are also expected to develop competencies to work on AI. However, given that AI development is not an easy and rather complex task, not all students may be capable of developing AI. Therefore, AI development is offered as an elective subject only for students in classes XI and XII. Second, the implemented Merdeka curriculum two years ago allows schools to offer elective subjects, making AI implementation as an elective subject feasible. Included the following are quotes from teachers and school administrators who are in favor of this approach.

> *In my ICT subject, there is indeed material on AI development in class XI, specifically covered in Chapter V of the informatics section. It focuses on developing mobile applications with AI libraries. However, this coverage is still quite limited. It is possible that there is no dedicated AI subject, so AI content can be incorporated into the ICT subject in class X. However, for more advanced content, it can be introduced as an elective subject in classes XI and XII. (Teacher: Denpasar)*

> *In my opinion, AI can be designated as both a compulsory and an elective subject. For class X, AI can be made a compulsory subject covering basic AI concepts. However, for those interested in creating AI, it is a challenging task and, therefore, this is only for those with a specific interest. (Head Teacher: Yogyakarta)*

The third model involves making AI an extracurricular activity. Teachers and school management who agree with this model express that there are already numerous subjects in schools, and introducing AI as a new mandatory subject is not the right choice as it would add to the students' workload. According to them, the best option is to keep AI limited to extracurricular activities, catering to students who have an interest in AI. Knowledge related to AI that students must possess can be incorporated into one or two chapters of the ICT subject, minimizing the burden on students. Additionally, schools will not face the challenge of providing a permanent AI teacher; if AI is an extracurricular activity, schools can seek freelance or part-time AI teachers. Here is a quote from teachers and school management supporting the third model:

Currently, the curriculum is already very dense and can impose a heavy burden on students. Students have the ability to learn independently, especially with the current technological advancements. Children are accustomed to using technology, such as smartphones, and many of them spend time playing online games. Some even participate in e-sports and achieve notable accomplishments. Therefore, activities related to AI can be integrated as extracurricular activities for students who have an interest and talent in that field. (Teacher: Samarinda)

If there is an AI curriculum to be introduced in a madrasah or school, we are very supportive. However, communication with relevant parties regarding the curriculum development is necessary. This is to ensure that the burden on students is not too heavy, allowing them to enhance specific skills in certain subjects rather than having only superficial knowledge about many things, so it should be considered as an extracurricular activity. (Head Teacher: Jembrana)

From the teacher's perspective, students already bear a considerable learning load in the classroom. If AI education is to be internalized into the curriculum, one option is to utilize extracurricular activities outside the classroom. Extracurricular activities in schools are learning activities conducted outside the regular classroom hours. The implementation of extracurricular learning activities aims to accommodate students' talents and interests that may not be fully addressed in the regular classroom learning process. It can be interpreted that these activities are optional for students based on their individual talents and interests.

Implementing AI education through extracurricular activities not only accommodates students' talents and interests but also enhances their engagement in the learning process. This results correlates with previous research findings indicating that students' involvement in extracurricular AI learning can improve understanding, ethical awareness, and the social implications of AI usage [22]. In addition, this results agree with the findings of other studies, in which placing AI education as an extracurricular activity also has implications for enhancing students' interpersonal skills, such as leadership and collaboration abilities [23], [24].

3.2. Teachers' competencies

AI learning in schools requires teachers who are competent in the field of AI. Teachers who understand AI, such as ICT teachers, are needed. Teachers with backgrounds in science, mathematics, or other subjects who have an understanding of AI can be considered as AI learning teachers. The main thing to note is the competence that these teachers must possess. Based on the focus group discussions conducted, it is evident that teachers who teach AI must have several key competencies. First, teachers who will teach AI must master basic AI knowledge, such as machine learning, internet of things, neural networks, and AI algorithms. Second, teachers must have the ability to teach gow to develop AI products. Third, teachers must understand the concept of ethics in AI and teach it to students. Finally, teachers must be willing to adapt to technology and continue learning about AI developments. This is evident from the following quotes:

At present, almost all schools do not have teachers with an informatics background because graduates in informatics often choose not to become teachers due to their non-educational background and the allure of higher salaries in IT companies. As a result, science and mathematics teachers with IT skills are often designated as ICT teachers. Of course, they can become AI teachers if they possess knowledge about AI and robotics. (Head Teacher: Samarinda)

In my opinion, younger teachers are closely acquainted with the internet and AI. They understand ICT and AI even if they do not have an informatics background. Therefore, they can become AI teachers if they have competencies in areas such as AI usage, AI development, AI ethics, and other AI-related aspects. They certainly already have personal, social, and pedagogical competencies because they are teachers (Teacher: Palembang)

Considering the absence of specific AI teachers in schools, if AI is to be incorporated into the curriculum, either as an intracurricular or extracurricular activity, it is essential to conduct training to prepare prospective AI teachers. Teachers need to be equipped with the competencies mentioned above as part of their professional skills while maintaining their personal, social, and professional competencies. Providing effective training will yield prospective AI teachers with comprehensive AI knowledge, the necessary skills, and a readiness to face the ongoing challenges of evolving technology. This is reflected in the following quotes:

Before teachers start teaching AI, they need to undergo sufficient training. They should be equipped with knowledge related to AI, understanding IoT, machine learning, coding, and programming. So, even if they don't have a background in informatics, with a strong willingness to learn AI and receiving adequate training, teachers can teach AI. (Teacher: Bogor)

The junior teachers appointed to teach AI must undergo sufficient training, similar to when the government conducted training for prospective ICT teachers 10 or 15 years ago. Prospective AI teachers should participate in structured training with content lasting approximately 6-12 months. During the training, prospective AI teachers are relieved of their regular duties, allowing them to focus on learning AI. (Teacher Yigyakarta)

As can be seen from the excerpts above, the improvement of teacher competence through training activities or workshops is one way to support the effective and efficient implementation of AI learning processes. This aligns with students' needs to master various 21st-century skills such as critical thinking, problem-solving, and collaboration. Professional development for teachers is necessary to assist them in learning and refining the pedagogy required to teach AI topics, simultaneously enhancing the aforementioned skills [15]. This is in accord with recent studies indicating that effective teacher competence development has several characteristics, including a focus on teachers' needs, alignment with technological advancements, clear training instructions, active teacher engagement, provision of adequate time and resources, ongoing support, collaboration, and addressing local needs [25], [26].

3.3. Content of artificial intelligence curriculum

In the learning process, AI can be viewed both as content and as a supportive tool. In practice, AI-related materials have been taught in the 11th-grade ICT subject. However, it only constitutes one chapter, providing a general overview of AI. The ICT subject itself, within the independent curriculum, holds an elective status, making it optional for students who wish to delve into informatics. As mentioned in the first point, the ICT subject can be considered an option to be developed for AI learning. This means that the learning content in the ICT subject can be focused on topics related to AI. In addition to emphasizing AI knowledge and skills, the AI learning process should also consider the development of students' characters, including creativity, critical thinking, responsibility, interaction with peers, and independence. The internalization of these characters can be achieved through both within and outside AI learning activities. This can be seen in the following quote:

The materials needed to support AI lessons include mechanics, modern physics, data science, coding, and programming. (Teacher-Samarinda)

There are many contents that must be used as materials in the teaching content, such as AI in daily life, AI ethics, programming languages, and machine learning. The curriculum can also help students design and create AI products, not just plug and play. (Teacher: Palembang)

Teachers should teach us about the use of AI in education and also explain the positive and negative impacts of AI. (Student: Jembrana)

If there is an AI curriculum, in my opinion there should be the use of AI, its benefits, and impacts. We should also be taught coding, programming, and creating simple AI products. (Student: Yogyakarta)

From the quotes above, it can be seen that teachers and students share a similar perspective on the content that needs to be included in the curriculum. This seems to be consistent with other research which found hat in AI learning projects, students are provided with knowledge about coding or robotics in high school [27], [28]. In accordance with this, previous study explains the AI learning framework, which is divided into several level. There are four levels of AI materials: social, ethical considerations (SE level). This level is related to understanding machine learning and AI; applications (A level). This level is related to understanding systems that include AI and the ability to create applications using machine learning systems models (M). This level is related to the ability to explore machine learning created by someone, understanding the process of selecting and removing data to train simple machine learning engines (E level). This level is related to the ability to explain how decision trees can be used to classify items [29].

3.4. Teaching strategies and asssesments

The learning process that can be implemented for AI education involves providing basic concepts about AI followed by hands-on practice. Emphasis on AI materials is more focused on developing critical thinking and digital skills. Teachers can utilize several learning strategies such as problem-based learning (PBL), project-based learning (PjBL), and science, technology, engineering, and math (STEM)-based product-oriented learning approaches.

AI is similar to the ICT teaching I conduct; it should be approached using various methods such as problem-solving and project-based learning. (Teacher: Denpasar)

In my opinion, it is more suitable for practice, the STEM approach, children constructing knowledge, collaboratively engineering solutions, incorporating mathematics, logical reasoning, and utilizing the latest technological advancements; STEM is more appropriate. (Teacher: Palembang)

AI learning should be taught more through practice and hands-on activities; there's no need for extensive theory. Therefore, group work and product creation can be utilized as learning strategies. (Student: Jembrana)

Maybe similar to ICT, in the beginning, the teacher explains the theory, but then there is more practical application. So, AI lessons involve more practice and collaborative projects. (Student: Depok)

As can be seen from quotes above, project-based learning should be considered as one option for delivering materials on AI. Several studies on the use of project-based learning in AI education have shown positive outcomes. A previous study indicated that project-based learning can enhance students' understanding of two of the most popular algorithms in AI [30]. Project-based learning, supported by the use of the Scratch programming language, was implemented in this research. In conformity tith this another research were also demonstrated that group-based project-based learning can provide in-depth understanding to learners regarding AI and its practical applications in daily life [31].

In the assessment aspect, teachers should implement authentic assessments according to students' needs and the goals of AI learning. Teachers can implement various assessment models, such as pre-post tests, paper-based exams, performance assessments, poster assessments, presentation assessments, and others. This assessment approach is designed to reflect students' deep understanding of AI material while simultaneously measuring practical abilities and skills required in the context of AI. In my opinion, learning.

AI is a new knowledge for students, so it is necessary to assess students' knowledge. Therefore, there should be pre-tests and post-tests to measure learning progress (Teacher: Palembang)

AI learning is best approached through direct practice, allowing skill aspects to be assessed using a scoring rubric. Meanwhile, observation instruments are employed to evaluate aspects of attitudes developed during AI learning. (Teacher: Bogor)

Tecaher may used different type of assement. We may be assessed through exam if we learn theory. However, if working on a project, the assessment might include performance, presentations, and the results of the project undertaken. (Student: Yogyakarta)

From various opinions expressed by teachers and students, asessment models that can be used in AI learning include process evaluation and result evaluation. Process evaluation and result evaluation are used to measure students' abilities in cognitive, affective, and skill aspects. Through the displayed works, teachers can observe whether students have successfully completed group activities and their ability to solve problems [32].

3.5. Ethical issues on artificial intellgence

The need for AI learning in high schools is inevitable. However, the integration of AI into daily life has raised concerns about the emergence of negative impacts. AI, as a tool and technology, is believed to have both positive and negative effects. Therefore, the AI curriculum must cover aspects related to AI ethics, addressing both the positive and potentially negative impacts of AI. Here are quotes from teachers and students regarding AI ethics in the learning.

The downside of AI is that children spend more time using technology, leading to a neglect of religious practices and cultural traditions. Additionally, there is a risk of reduced job opportunities as many jobs may be replaced by AI. If AI is to be taught in schools, it is essential to strengthen ethics and set limits on the material provided to prevent students from going astray. (Head Teacher: Samarinda)

AI provides many conveniences in life. However, there are also drawbacks. What concerns us is the negative impact of AI, such as its potential use for criminal activities, including cheating and plagiarism when completing assignments. Therefore, AI ethics must be considered by teachers and students and integrated into AI learning. (Teacher: Yogyakarta)

The progress of AI has been widely utilized in education, such as using Chat GPT, creating presentations with AI tools, and more. While this is beneficial in some aspects, it also has drawbacks. The presence of AI can lead to a generation that becomes lazy, unwilling to think critically, and resorting to plagiarism in their assignments, relying too much on AI. Therefore, there should be education on the ethics of utilizing and developing AI to ensure responsible use. (Student: Yogyakarta)

The quotes above indicate a consensus among both teachers and students that AI, much like other technologies, possesses both advantageous and disadvantageous aspects. The disadvantage impacts of AI, such as creating a lazy generation, engaging in criminal activities, and developing irresponsible AI products, are concerns for both teachers and students. Therefore, the ethical aspect of AI must receive more attention and be incorporated into AI education and curriculum development. A curriculum developed with design principles encompassing active learning, integrated ethics, and easy access can assist students in becoming knowledgeable users and creators of AI [33], [34].

4. CONCLUSION

The research explored five key themes identified through thematic analysis, providing valuable perspectives on how to successfully incorporate AI into secondary education. Firstly, three proposed models for curriculum implementation are explored: making AI compulsory for all students, making it compulsory for class x and elective for classes XI and XII, and presenting AI as an extracurricular activity. Stakeholders advocating for each model express their views, emphasizing the necessity of AI education and the need to balance accessibility with the complexity of AI development. Secondly, the study underscores the importance of teacher competencies in AI education. Teachers, particularly those in ICT or with science and mathematics backgrounds, need to master basic AI knowledge, teach AI product development, understand AI ethics, and adapt to evolving technological landscapes. The study suggests comprehensive training programs to equip teachers with the required competencies. Thirdly, AI is positioned both as content and a supportive tool in the learning process. The current practice involves introducing AI-related materials in the 11th-grade ICT subject, with a call to consider ICT as a viable option for AI learning. The emphasis is not only on developing AI knowledge and skills but also on nurturing students' character traits, including creativity and critical thinking. Based on the results the researchers recommend further studies should be undertaken to investigate the long-term impacts of AI learning, exploring its effects on students' ethical awareness, critical thinking abilities, and practical skills. Investigating the societal implications of AI education is crucial, encompassing aspects such as its influence on students' career choices and their contributions to the ongoing development of AI technology. This comprehensive research agenda is essential for the continued advancement of AI education in high schools, fostering a deeper understanding of its multifaceted impacts and potential improvements.

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