

TRANSFORMATION OF VOCATIONAL HIGH SCHOOL LEARNING THROUGH THE INTEGRATION OF ARTIFICIAL INTELLIGENCE IN THE PROJECT-BASED LEARNING (PJBL) MODEL

TRANSFORMASI PEMBELAJARAN SEKOLAH MENENGAH KEJURUAN MELALUI
INTEGRASI KECERDASAN BUATAN DALAM MODEL PEMBELAJARAN BERBASIS
PROYEK (PJBL)

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ABSTRACT

The transformation of learning in Vocational High Schools (SMK) has become an urgent necessity in line with technological advancements and the demands of the industrial world in the era of the Industrial Revolution 4.0. This study aims to examine the transformation of SMK learning through the integration of Artificial Intelligence (AI) in the Project-Based Learning (PjBL) model. The method used is a qualitative approach with a type of research in the form of a literature study (library research), which reviews various scientific sources related to vocational learning, PjBL, and the utilization of AI in education. Data analysis was conducted using content analysis techniques to identify patterns and relationships among concepts. The results of the study indicate that SMK learning has competency-based characteristics, is oriented toward the world of work, and integrates theory and practice. The PjBL model has proven effective in enhancing student engagement, higher-order thinking skills (HOTS), as well as 21st-century skills such as critical thinking, creativity, communication, and collaboration. Meanwhile, AI plays a role in supporting adaptive learning through the personalization of materials, automated feedback, and learning data analysis. The integration of AI in PjBL can be implemented through the use of AI as a research tool, industrial work simulation, and data-based learning evaluation. In conclusion, the integration of AI in the PjBL model is an innovative strategy that can improve the quality of learning in SMK to become more contextual, adaptive, and relevant to industry needs. This transformation is important for producing graduates who are competent, innovative, and ready to face the challenges of the workforce in the digital era

Keywords: Artificial Intelligence, Project-Based Learning, Vocational High School (SMK), Vocational Learning

ABSTRAK

*Transformasi pembelajaran di Sekolah Menengah Kejuruan (SMK) telah menjadi kebutuhan mendesak seiring dengan kemajuan teknologi dan tuntutan dunia industri di era Revolusi Industri 4.0. Penelitian ini bertujuan untuk mengkaji transformasi pembelajaran SMK melalui integrasi Kecerdasan Buatan (AI) ke dalam model *Project-Based Learning* (PjBL). Metode yang digunakan adalah pendekatan kualitatif dengan jenis penelitian studi pustaka (*library research*), yang menelaah berbagai sumber ilmiah terkait pembelajaran vokasi, PjBL, dan pemanfaatan AI dalam pendidikan. Analisis data dilakukan menggunakan teknik analisis konten untuk mengidentifikasi pola dan hubungan antar-konsep.*

*Hasil penelitian menunjukkan bahwa pembelajaran SMK memiliki karakteristik berbasis kompetensi, berorientasi pada dunia kerja, serta mengintegrasikan teori dan praktik. Model PjBL terbukti efektif dalam meningkatkan keterlibatan siswa, keterampilan berpikir tingkat tinggi (*Higher-Order Thinking Skills* atau HOTS), serta keterampilan abad ke-21 seperti berpikir kritis, kreativitas, komunikasi, dan kolaborasi. Sementara itu, AI berperan dalam mendukung pembelajaran adaptif melalui personalisasi materi, umpan balik otomatis, dan analisis data pembelajaran. Integrasi AI dalam PjBL dapat diterapkan melalui penggunaan AI sebagai alat bantu riset, simulasi kerja industri, dan evaluasi pembelajaran berbasis data. Sebagai kesimpulan, integrasi AI dalam model PjBL merupakan strategi inovatif yang dapat meningkatkan kualitas pembelajaran di SMK agar lebih kontekstual, adaptif, dan relevan dengan kebutuhan industri. Transformasi ini penting untuk menghasilkan lulusan yang kompeten, inovatif, dan siap menghadapi tantangan dunia kerja di era digital.*

Kata kunci: Kecerdasan Buatan, Pembelajaran Berbasis Proyek, Sekolah Menengah Kejuruan (SMK), Pembelajaran Vokasi

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INTRODUCTION

Learning in Vocational High Schools (SMK) is an educational process oriented toward mastering job competencies in accordance with the needs of the business and industrial sectors. Unlike general education, learning in SMK emphasizes a balance between theory and practice, enabling students not only to understand concepts but also to apply them in real-world contexts. The primary goal is to produce graduates who are job-ready, adaptive to change, and equipped with both technical skills and soft skills relevant to contemporary developments.

According to Sudira (2016), vocational education is designed to produce graduates who possess work competencies aligned with industry needs through a combination of theory and practice. In line with this, Hadi (2018) states that SMK plays an important role in preparing a workforce that is ready to use and adaptive to changes in the world of work, while Wena (2019) emphasizes the importance of balancing cognitive, psychomotor, and affective aspects in learning. From these statements, it can be understood that education in Vocational High Schools (SMK) is oriented toward students' job readiness through learning that integrates theory and practice in a balanced manner. The educational process not only emphasizes mastery of knowledge but also focuses on developing skills relevant to the needs of the industrial world. Therefore, learning in SMK must be designed in a contextual and applicative manner to reflect real working conditions and equip students with competencies that meet labor market demands.

In addition, learning in SMK also requires the development of students' adaptive abilities in facing the dynamic changes of the world of work, including technological advancements. This implies the importance of fostering critical thinking, problem-solving skills, and flexibility. The success of vocational education is not only determined by skill aspects but also by the balance between cognitive, psychomotor, and affective domains. Therefore, SMK learning needs to be designed holistically to produce graduates who are not only technically competent but also possess strong knowledge and professional attitudes.

To achieve these goals, learning in SMK is generally designed using a competency-based curriculum that refers to industry standards. In addition, activities such as industrial work practice (PKL), teaching factory, and competency certification are essential components in strengthening students' job readiness. Through this approach, students not only learn in the classroom but also gain direct experience in real working environments.

Kuswantoro (2017) explains that the teaching factory is a learning model that integrates real production processes into learning activities in SMK. Suyitno (2020) also states that industrial work

practice is effective in improving student competencies, while various studies adapting Rojewski's ideas show that work-based learning can bridge the gap between education and the world of work. In this context, it can be understood that learning in SMK is increasingly directed toward approaches that present real work experiences as an integral part of the educational process. Learning models that integrate production activities into the learning environment enable students not only to understand concepts but also to directly experience work processes as they occur in the industrial world. Thus, learning becomes more contextual, applicative, and relevant to workforce needs.

Work-based learning experiences, such as industrial work practice and work-based learning approaches, have proven to enhance students' competencies while bridging the gap between education and industry needs. This approach provides students with opportunities to develop technical skills, professional attitudes, and an understanding of workplace culture. Therefore, integrating real-world experience into learning is an important strategy for producing SMK graduates who are job-ready and capable of adapting to industrial demands.

In practice, one of the effective learning models used in SMK is Project-Based Learning (PjBL). Through this model, learning is designed around projects that encourage students to solve real problems collaboratively and contextually. Rais (2017) states that PjBL can increase student engagement through project-based activities. This is supported by Kurniawan (2019), who found that PjBL enhances students' practical skills, and Sumarni (2018), who emphasizes that this model is relevant to the characteristics of vocational education.

Project-based learning is one of the most effective approaches in vocational education because it provides active, contextual, and problem-oriented learning experiences. Through collaborative projects, students are encouraged to be directly involved in the learning process, thereby increasing their participation and engagement. This model has also been proven to develop practical skills, which are essential in vocational education. Its alignment with the characteristics of vocational learning makes it highly relevant for preparing students for the workforce, as it emphasizes not only theoretical mastery but also practical abilities and real-world experience in completing tasks or projects.

The PjBL model also provides opportunities for students to develop higher-order thinking skills. In the process, students conduct research, planning, and evaluation of outcomes. Nurhadi (2018) states that PjBL encourages the development of critical and creative thinking skills. Fitri (2020) adds that this model strengthens 21st-century skills, while Anazifa (2017) shows that PjBL is effective in improving problem-solving abilities and teamwork. From these statements, it can be understood that Project-Based Learning (PjBL) is an effective approach in developing various essential skills needed by students in the modern era. Through active involvement in projects, students are encouraged to think critically and creatively in solving given problems. This process not only requires conceptual understanding but also the ability to process information, make decisions, and generate innovative solutions. PjBL also plays a role in strengthening 21st-century skills such as problem-solving and teamwork. In its implementation, students are trained to collaborate, communicate effectively, and take responsibility for group tasks. Thus, this model not only enhances cognitive aspects but also fosters social skills and attitudes that support students' readiness to face workplace challenges and real-life situations.

Along with the rapid development of technology, particularly Artificial Intelligence (AI), the transformation of learning in SMK has become inevitable. Lase (2019) states that the Industrial Revolution 4.0 requires the education sector to adapt to digital technologies. Prasetyo and Sutopo (2018) also explain that technology-driven industrial changes demand new competencies, while Rahmawati (2021) emphasizes that AI integration can improve the quality of learning.

In this regard, it can be understood that rapid technological advancements, especially in Artificial Intelligence (AI), require transformation in SMK learning to remain relevant to contemporary needs. Changes driven by the Industrial Revolution 4.0 push the education sector to adapt by utilizing digital technology in the learning process. This indicates that learning systems can no longer remain conventional but must integrate technology as a key component in improving learning effectiveness and efficiency.

Technological advancements in industry also demand new competencies from students, such as digital literacy, critical thinking, and technological skills. In this context, integrating AI into learning becomes a strategic solution to improve the quality of education, both in terms of content delivery, personalized learning, and competency development. Therefore, transforming SMK learning through the use of AI is an important step in preparing graduates who are adaptive, competent, and ready to face the challenges of the digital era.

The development of AI has also transformed work patterns across various sectors. Widodo (2019) states that digital transformation shifts workforce competency needs toward non-routine skills. Sari (2020) explains that automation impacts job structures, while Handayani (2021) emphasizes that AI requires a more adaptive workforce.

The transformation of SMK learning through AI integration can be achieved by incorporating AI technologies into the PjBL model. Putra (2022) states that AI integration can enhance students' creativity in project-based learning. Hidayat (2021) emphasizes that teachers act as facilitators in the digital era, while Santoso (2023) states that AI can serve as an innovative learning medium. This means that the role of teachers has shifted from being the primary source of information to becoming facilitators who guide and direct students' learning processes. Teachers are no longer the sole source of knowledge but play a role in creating learning environments that encourage independence, exploration, and optimal use of technology by students.

The presence of Artificial Intelligence (AI) as an innovative learning medium opens new opportunities to improve the quality and effectiveness of education. This technology enables more interactive, adaptive, and personalized content delivery according to students' needs. Thus, the integration of teachers' roles as facilitators and the use of AI in learning can create more modern, flexible, and technology-relevant learning experiences. This integration also opens opportunities for more personalized and adaptive learning. Wibowo (2021) states that AI enables learning tailored to students' needs. Pramudita (2020) adds that AI can provide rapid feedback, while Kusuma (2022) emphasizes the importance of digital ethics in its use.

The urgency of this transformation lies in the need to prepare competent and innovative graduates. Yusuf (2021) states that vocational education must integrate 21st-century skills. Setiawan (2022) emphasizes the importance of technology-based learning innovation, while Trilling and Fadel (2009) highlight the importance of 4C skills.

In this context, it can be understood that vocational education needs to integrate 21st-century skills as an essential part of the learning process. This indicates that students are not only required to master technical skills but must also possess competencies relevant to current developments, such as critical thinking, creativity, and adaptability. Therefore, learning must be designed in a more modern way by utilizing technology as a means to support competency achievement.

Furthermore, technology-based learning innovation is key to developing 21st-century skills, particularly the 4Cs: critical thinking, creativity, communication, and collaboration. These skills are essential in preparing students to compete and contribute in an increasingly complex world of work. Thus, integrating technology and strengthening 4C skills in vocational education is a strategic step toward producing graduates who are competent, adaptive, and ready to face global challenges. In other words, this transformation requires support from various stakeholders, as explained by Mulyadi (2020), who highlights the importance of collaboration between education and industry. Rahman (2021) also emphasizes the importance of an innovative educational ecosystem supported by multiple parties.

Based on the above discussion, it can be concluded that the transformation of SMK learning through the integration of Artificial Intelligence (AI) in the Project-Based Learning (PjBL) model is a strategic step that is not only relevant but also urgent. The combination of project-based learning approaches with AI technology can create a more contextual, adaptive, and industry-oriented learning process. This enables students to develop both technical competencies and 21st-century skills, including critical thinking, creativity, collaboration, and communication. With the support of teachers as facilitators and synergy between education and industry, this transformation is expected to produce SMK graduates who are not only job-ready but also innovative, flexible, and competitive in the ever-evolving digital era.

METHODS

This study employs a qualitative approach using a literature study (library research) method. Data were obtained from various scientific sources, such as national journals, books, and previous research findings relevant to the topics of vocational high school (SMK) learning, Project-Based Learning (PjBL), and the integration of Artificial Intelligence (AI) in education. The data collection technique was conducted through the identification, classification, and analysis of literature related to the research variables. Furthermore, the data were analyzed using content analysis techniques to identify patterns, concepts, and relationships among variables that support the transformation of learning in SMK. This approach was chosen because it provides an in-depth conceptual and theoretical understanding of integrating AI into project-based learning models, as well as its relevance to the needs of vocational education in the digital era.

RESULT AND DISCUSSION

1. Characteristics of Vocational High School (SMK) Learning

The results of the study indicate that learning in vocational high schools (SMK) has key characteristics, namely orientation toward the world of work, integration of theory and practice, and an emphasis on competencies. Models such as the teaching factory and industrial work practice (internships) play an important role in shaping students' work readiness. In this context, the learning process no longer focuses solely on mastering concepts, but rather on students' ability to apply that knowledge in real situations relevant to industry needs. Thus, SMK graduates are expected not only to understand theory but also to possess mental readiness and practical skills in accordance with workplace standards.

Hadi (2018) explains that vocational education is oriented toward the needs of the labor market. Sudira (2016) emphasizes that TVET highlights the balance between theory and practice. Kuswantoro (2017) states that the teaching factory is a relevant learning model for bringing students closer to the industrial world, while Suyitno (2020) shows that industrial work practice is effective in improving students' work readiness.

In this regard, it can be understood that vocational education is designed with a strong orientation toward the needs of the workplace, so that the learning process does not only focus on theoretical mastery but also emphasizes relevant practical skills. The balance between theory and practice becomes a key element to ensure that students have both conceptual understanding and technical abilities that can be directly applied.

Furthermore, learning is directed to closely resemble real industrial conditions, one of which is through production-based or work-simulation models that allow students to learn in situations similar to actual workplaces. Direct experience in industrial environments is also considered important, as it strengthens work readiness in terms of skills, attitudes, and understanding of work culture. Thus, the effectiveness of vocational education largely depends on the integration between school-based learning and real-world industrial experience, ensuring that graduates possess competencies aligned with labor market demands.

The implementation of the teaching factory allows students to learn in environments that resemble real industries, making them familiar with work culture, operational standards, and productivity demands. Meanwhile, industrial work practice provides direct experience for students to interact with the professional world, understand teamwork dynamics, and develop communication and adaptability skills. The combination of these two models strengthens contextual and relevant learning processes, thereby significantly reducing the gap between education and industry.

Kuswantoro (2017) explains that the teaching factory integrates real production processes into learning. Suyitno (2020) emphasizes that direct industrial experience strengthens students' competence and adaptability. This means that vocational learning is designed to be as close as possible to real working conditions through the integration of production processes into learning activities. With this approach, students not only learn concepts but also engage directly in activities that reflect industrial

practices, making learning more contextual and applicable. Direct experience in industrial environments has a significant impact on strengthening student competencies. This involvement not only enhances technical skills but also helps students adapt to work culture, production rhythms, and professional demands, making them better prepared for the workforce.

Experience-based learning has been proven to improve both technical and non-technical skills of students. Technical skills include mastery of tools, work procedures, and technologies used in their respective fields, while non-technical skills include critical thinking, problem-solving, teamwork, and work ethic. Both types of skills are essential in the modern, dynamic, and competitive workplace. Therefore, a learning approach that positions students as active participants in the learning process is key to producing excellent and adaptive graduates.

Wena (2019) states that experience-based learning improves students' practical skills. Trilling and Fadel (2009) emphasize the importance of 21st-century skills such as critical thinking and collaboration. Yusuf (2021) also highlights that these skills are essential in vocational education. Experience-based learning plays an important role in enhancing students' practical skills, as it provides opportunities to learn through direct and contextual activities. This approach enables students not only to understand material but also to develop the ability to apply knowledge in real situations. The importance of 21st-century skills such as critical thinking and collaboration is a major emphasis in vocational education. These skills are considered essential for students to adapt to the dynamics of the modern workplace, meaning that vocational education should focus not only on technical aspects but also on developing effective thinking and teamwork abilities.

Strengthening experience-based learning also contributes to shaping students' work character, such as discipline, responsibility, and professionalism. These values cannot be optimally achieved through theoretical learning alone but must be instilled through direct practice and habituation in real work environments. This shows that SMK functions not only as an educational institution but also as a platform for developing work character and culture aligned with industry demands. Thus, the role of SMK as an institution bridging education and industry needs is further reinforced. The success of SMK in producing competent graduates depends greatly on how well the curriculum and learning models adapt to industrial developments. Therefore, synergy between schools, businesses, and industries is a crucial factor in ensuring the relevance and sustainability of vocational education in the future.

Rahman (2021) explains that contextual learning contributes to the formation of work character. Mulyadi (2020) emphasizes the importance of collaboration between education and industry in improving graduate quality.

2. Effectiveness of the Project-Based Learning (PjBL) Model

The Project-Based Learning (PjBL) model has proven effective in increasing student engagement and developing higher-order thinking skills (HOTS). In this model, students are trained to solve real problems through structured projects, making the learning process more meaningful and not merely focused on final outcomes. Anazifa (2017) explains that PjBL influences students' problem-solving abilities. Nurhadi (2018) states that PjBL is effective in improving HOTS. Active student involvement in every stage of the project—from planning, implementation, to evaluation—encourages analytical thinking, decision-making, and independent reflection. Thus, PjBL not only enhances conceptual understanding but also builds strong independent learning skills.

PjBL also significantly contributes to the development of 21st-century skills needed in the modern workforce. First, critical thinking develops through problem identification, data analysis, and evidence-based conclusions. Second, creativity is fostered when students are required to produce innovative and relevant solutions or products. Third, communication is strengthened through presentations, discussions, and systematic reporting. Fourth, collaboration becomes essential since most projects are conducted in groups, teaching students to work together, share roles, and resolve conflicts constructively.

Fitri (2020) states that PjBL improves 21st-century skills. Trilling and Fadel (2009) emphasize the importance of the 4Cs in the workplace. Yusuf (2021) also highlights the relevance of these skills in vocational education. In this regard, project-based learning plays a strategic role in developing 21st-

century skills, as it encourages students to actively engage in problem-solving, decision-making, and producing real outputs. Through this process, students not only gain knowledge but also develop critical thinking, creativity, communication, and collaboration skills in an integrated manner.

The implementation of PjBL also provides opportunities to integrate theoretical knowledge with practical application. Students do not only understand abstract concepts but also test them in real situations requiring interdisciplinary application. This aligns with industry demands for workers who are not only technically competent but also adaptable, flexible thinkers, and capable of working in cross-disciplinary teams. Kurniawan (2019) explains that PjBL is effective in SMK. Widodo (2019) emphasizes that the workforce requires adaptive and flexible individuals. Therefore, PjBL is highly relevant for SMK, which emphasizes contextual and applied learning.

3. The Role of Artificial Intelligence in Learning

Artificial Intelligence (AI) offers great opportunities to improve learning quality through adaptive and responsive innovations tailored to students' needs. One of AI's main advantages is its ability to personalize learning, where materials, pace, and difficulty levels can be adjusted to individual abilities. With this approach, students are no longer treated uniformly but are facilitated according to their learning styles and potentials. This significantly enhances learning effectiveness and reduces achievement gaps among students.

Pramudita (2020) explains that AI supports adaptive learning. Wibowo (2021) states that AI enables personalized learning. This means that AI utilization allows the creation of more adaptive learning processes tailored to students' needs and abilities. Additionally, AI enables effective personalization by analyzing student progress and providing appropriate recommendations, thus improving overall learning quality.

AI also enables automatic and rapid feedback, allowing students to immediately identify errors and make improvements. This instant feedback strengthens the learning process as students do not have to wait long for teacher evaluations. Furthermore, AI-driven data analysis can identify learning difficulties, map student needs, and recommend appropriate strategies. Santoso (2023) states that AI provides automatic feedback, while Pramudita (2020) highlights the role of AI in data-driven learning strategies.

4. Integration of AI in the PjBL Model in SMK

The integration of AI in PjBL can be implemented through various strategies that enhance project-based learning. One example is using AI as a research tool, enabling students to search, process, and analyze information more quickly and accurately. AI also supports industrial work simulations, allowing students to practice real-world scenarios without always being physically present in industry settings.

AI-based platforms for evaluation and feedback further strengthen PjBL effectiveness by providing fast, objective, and continuous assessments. Feedback becomes not only corrective but also constructive, helping students understand their strengths and weaknesses more deeply. Rahmawati (2021) states that AI supports information exploration, while Santoso (2023) emphasizes its role in learning simulations. AI integration also encourages students to develop technology-based products, enhancing creativity, innovation, and real-world applicability. In this context, the teacher's role transforms from the main source of information to a facilitator guiding students in using technology effectively and ethically. Hidayat (2021) highlights the teacher's role in the digital era, while Kusuma (2022) emphasizes the importance of ethics in technology use.

5. The Urgency of Learning Transformation

The transformation of learning in SMK is an urgent necessity in response to changes in the workforce driven by the Industrial Revolution 4.0. Technological developments such as automation, big data, and AI have fundamentally changed industrial operations, requiring education systems to adapt quickly. SMK, as a vocational institution, has a strategic responsibility to ensure graduates are not only job-ready but also adaptable to ongoing changes. This transformation requires a shift from basic technical skills toward more complex competencies such as critical thinking, creativity, problem-solving,

collaboration, and digital literacy. Without these, graduates risk a mismatch with industry needs. Automation has also altered job structures, replacing many routine tasks. Handayani (2021) states that AI is transforming the workforce, while Sari (2020) explains the impact of automation on labor. This condition demands skills that cannot easily be replaced, such as complex problem-solving and creativity.

Another urgency is mastering 21st-century skills (4C). These skills are fundamental in facing an increasingly complex and competitive job market. Industry also demands adaptive workers capable of lifelong learning and cross-disciplinary collaboration. Therefore, integrating AI into Project-Based Learning (PjBL) is a strategic solution to improve vocational education quality. Putra (2022) and Rahmawati (2021) explain that the combination of AI and PjBL creates adaptive and contextual learning. This integration enables students to engage in real-world problem-solving while benefiting from personalized, technology-supported learning.

Through this approach, students gain not only knowledge and skills but also meaningful learning experiences aligned with modern workplace demands. Thus, technology-based transformation in SMK learning is a crucial step in producing competent, innovative graduates ready to face future challenges.

CONCLUSION

Learning in Vocational High Schools (SMK) plays a highly strategic role in preparing competent, adaptive human resources who are ready to compete in the industrial world. In this context, the implementation of the Project-Based Learning (PjBL) model has proven to be an effective approach, as it is capable of integrating knowledge, skills, and attitudes simultaneously. Through PjBL, students not only gain conceptual understanding but also develop critical thinking skills, creativity, and collaboration abilities that are essential in real work environments. Thus, learning in SMK is no longer oriented toward memorization, but toward the mastery of competencies that are applicable and relevant to industry needs.

The implementation of PjBL encourages students to actively engage in the learning process, positioning them as subjects who construct knowledge rather than merely objects who receive information. This involvement is reflected in activities such as planning, implementing, and evaluating projects that resemble workflows in the industrial world. Such direct experiences provide students with opportunities to understand real work dynamics, including problem-solving, time management, and teamwork. Therefore, PjBL not only improves learning outcomes but also strengthens students' work readiness through contextual and meaningful learning experiences. Along with the rapid advancement of technology, particularly Artificial Intelligence (AI), the integration of this technology into learning has become an unavoidable necessity. AI enables the creation of more personalized, adaptive, and interactive learning through real-time analysis of student learning data. Furthermore, AI can assist teachers in designing learning that meets individual student needs, providing automated feedback, and simulating complex industrial scenarios. By integrating AI into the PjBL model, learning in SMK becomes increasingly relevant to the demands of the digital era, thereby producing graduates who are not only technically competent but also capable of utilizing technology to face future challenges..

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