Comparative Analysis of Agriculture Curriculum with Agronomy Concentration in Vocational High Schools in Germany and Indonesia

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Abstract

The German vocational education system has developed steadily over centuries and is recognized as a global reference in providing vocational education. This study compares the agricultural curriculum with agronomy concentration in vocational high schools in Indonesia with the vocational education system in Germany. The study is expected to be able to offer strategic recommendations for the development of agricultural vocational education in Indonesia, provide strategic insights for the development of a more relevant agricultural vocational high school curriculum, and be able to create promising career opportunities in agriculture. This study uses a qualitative approach with a content analysis design on the documents that are the primary analysis sources. The results show that Germany excels in integrating theory, practice, technology, and industry involvement through an intensive Duale Ausbildung system. The longer duration of education and the use of advanced technologies such as smart farming make Germany more prepared to face the industrial era 4.0. In contrast, Indonesia is starting to move towards innovation with a project-based learning approach, but industry involvement and recognition of competency certification are still limited. The study's conclusion shows that although the Indonesian agronomy curriculum has approached international standards, strengthening industrial partnerships, modern technology, and global certification recognition need to be improved to increase the competitiveness of graduates in the global market.

Keywords: Curriculum Comparison, Vocational High School, Agronomy, Germany, Indonesia

Abstrak

Sistem pendidikan kejuruan di Jerman telah berkembang secara stabil selama berabad-abad dan diakui sebagai rujukan global dalam penyelenggaraan pendidikan kejuruan. Penelitian ini bertujuan untuk membandingkan kurikulum pertanian konsentrasi agronomi pada SMK di Indonesia dengan sistem pendidikan kejuruan di Jerman. Penelitian diharapkan mampu menawarkan rekomendasi strategis bagi pengembangan pendidikan kejuruan pertanian di Indonesia, memberikan wawasan strategis untuk pengembangan kurikulum SMK pertanian yang lebih relevan, dan mampu menciptakan peluang karir yang menjanjikan di bidang pertanian. Penelitian ini menggunakan pendekatan kualitatif dengan desain analisis konten pada dokumen-dokumen yang menjadi sumber utama analisis. Hasil penelitian menunjukkan bahwa Jerman unggul dalam integrasi teori, praktik, teknologi, dan keterlibatan industri melalui sistem Duale Ausbildung yang intensif. Durasi pendidikan yang lebih panjang dan penggunaan teknologi canggih menjadikan Jerman lebih siap menghadapi era industri 4.0. Sebaliknya, Indonesia mulai bergerak ke arah inovasi dengan pendekatan pembelajaran berbasis proyek, namun keterlibatan industri dan pengakuan sertifikasi kompetensi masih terbatas. Kesimpulan penelitian menunjukkan bahwa meskipun kurikulum agronomi Indonesia telah mendekati standar internasional, penguatan kemitraan industri, adopsi teknologi modern, dan pengakuan sertifikasi secara global perlu ditingkatkan untuk meningkatkan daya saing lulusan di pasar global.

Kata Kunci: *Komparasi Kurikulum, Sekolah Menengah Kejuruan, Agronomi, Jerman, Indonesia*

Introduction

Agriculture is a vital sector that supports global food security and human life. However, this sector in Indonesia faces challenges in the form of low interest among the younger generation in pursuing a career in agriculture. The perception that agriculture is a traditional, less promising, and less prestigious field is the leading cause.[1] The global food security crisis further emphasizes the need for serious attention to increase productivity and innovation in this sector. [2] Overcoming this challenge requires cross-sector collaboration, including government, education, and society.

Vocational education in agriculture through vocational schools is designed to produce ready-to-use workers from an early age. However, data shows that student interest in agricultural majors in vocational schools is still around 50% until 2023 (see Figure 1).[3] The data in Figure 1 shows the distribution of student interest in various agricultural majors in vocational schools. Based on statistics from the PPSDMP Agency Secretariat (2023), student interest tends to be higher in majors such as Plantation Crop Agribusiness and Horticulture, indicating a preference for sectors that focus on crop production. The Independent Curriculum implemented in vocational schools provides freedom for contextual learning, but its implementation still requires further development. This effort is important so that the curriculum can attract the younger generation's interest while responding to global challenges. [4]

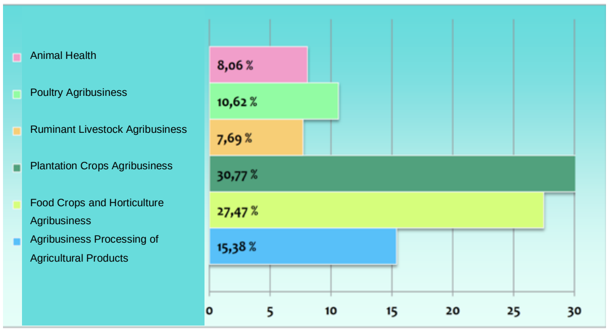

Figure 1. Statistical Data on Student Interest in Choosing Agricultural Majors
Source: (Secretariat of the PPSDMP Agency, 2023)

In comparison, Germany is known as a pioneer in vocational education through the Duale Ausbildung system, which integrates theoretical learning in schools with practical industry training. This system balances theory and practice, creating competent and work-ready graduates.[5] With the principle of decentralization, each state in Germany has the authority to set its curriculum but still refers to national guidelines to maintain the quality of education.[6] This structure allows flexibility while ensuring alignment with local industry needs. This makes vocational education graduates in Germany competitive in the global job market.[7]

The success of the vocational education system in Germany lies not only in the structure and teaching methods,[8] but also in the close

[1] Abdul Rasyid, 'Faktor-Faktor Yang Mempengaruhi Siswa Smk Dalam Pemilihan Jurusan Di Smk Pgri Tanjung Raja Abdul Rasyid', 0581 (2017), 54–58.

[2] Tecnical Cooperation Program IAEA, 'Agriculture and Food Security The IAEA Contribution TC Projects Help Member States Enhance Agricultural Productivity and Improve Food Security', *Iaea*, 2007.

[3] Badan Penyuluhan dan Pengembangan Sumber Daya Manusia Pertanian, *Data Statistik SDM PENDIDIKAN PERTANIAN 2023* (Jakarta: Kementerian Pertanian, 2023) <https://bppsdmp-ppid.pertanian.go.id/doc/19/03-Buku Statistik PENDIDIKAN 2023.pdf>.

[4] dan Teknologi Republik Indonesia Nomor 244/M/2024 Keputusan Menteri Pendidikan, Kebudayaan, Riset, 'Keputusan Menteri Pendidikan, Kebudayaan, Riset, Dan Teknologi Republik Indonesia Nomor 244/M/2024 Tentang Spektrum Keahlian Dan Konversi Spektrum Keahlian Sekolah Menengah Kejuruan/Madrasah Aliyah Kejuruan Pada Kurikulum Merdeka', 2022, 1–26.

[5] Melanie Oeben and Matthias Klumpp, 'Transfer of the German Vocational Education and Training System—Success Factors and Hindrances with the Example of Tunisia', *Education Sciences*, 11.5 (2021) <https://doi.org/10.3390/educsci11050247>.

[6] Heike Solga and others, 'The German Vocational Education and Training System: Its Institutional Configuration, Strengths, and Challenges', 2014, 1–42 <http://econstor.eu/bitstream/10419/104536/1/805013571.pdf>.

[7] Caroline Baumgarten and others, *Vocational Education and Training: Overview of The Professional Qualification Opportunities in Germany* (Germany, 2020).

[8] Mercedes Llorent-Vaquero, 'Religious Education in Public Schools in Western Europe', *International Education*

collaboration between schools and industry. In the Duale Ausbildung system, companies are the main partners who provide practical training and ensure the relevance of the learning material to the needs of the labour market. Certification issued by professional bodies, such as chambers of commerce and agricultural associations, guarantees the quality of the training. Students gain hands-on work experience tailored to their expertise, enabling them to master technical skills and build professional networks early on. In addition, the system is also supported by remuneration during the training period, which is an additional attraction for students.[9,10]

Vocational agricultural education in Indonesia, especially in the concentration of Food Crops and Horticulture Agribusiness (ATPH), has excellent potential to produce skilled workers. However, there are still challenges in attracting the younger generation's interest, especially related to innovation in curriculum and learning approaches. Integrating theory and practice in vocational schools is still less than optimal, while collaboration with industry has not been established systematically. A curriculum based on local needs and utilizing modern technology can be a solution. In addition, an approach relevant to the global market's needs can increase this sector's attractiveness.

In contrast, the German vocational education system offers valuable lessons for Indonesia in addressing challenges in this sector. The industry-led approach ensures that students gain relevant practical experience. In addition, internationally recognized certifications improve the quality of graduates, making them competitive in the global job market. Collaboration between educational institutions, industry, and government creates an educational ecosystem adaptive to global changes. This shows that integrating theory and practice, as well as industry involvement, is key to the success of vocational education.[11]

This study aims to compare Indonesia's agricultural vocational education system with Germany's to identify concrete solutions. Solutions include the development of a curriculum based on local needs that is integrated with modern technology. Strengthening strategic partnerships between education and industry is also needed to increase the relevance and competitiveness of graduates. Implementing an international standard certification system can ensure that the quality of education meets the needs of the global job market. Through this step, agricultural vocational education in Indonesia can become more attractive to the younger generation while contributing to the sustainable development of the agricultural sector.

Research Method

This study uses a qualitative approach with a descriptive design based on document analysis. The main objective is to comprehensively compare the agricultural curriculum in Germany and Indonesia, focusing on the analysis of key elements such as content, structure, learning approaches, industry and technology integration, evaluation and certification systems, graduate outcomes, and sustainability. This comparison aims to identify the strengths and weaknesses of each system in order to formulate strategic recommendations for the development of agricultural vocational education in Indonesia.

The research objects include official documents related to both countries' agricultural vocational education systems. The curriculum in focus is the Duale Ausbildung in Germany, which emphasizes integrating theory and practice through collaboration with industry. The Merdeka Curriculum in 2024 was implemented in

Studies, 11.1 (2017), 155 <https://doi.org/10.5539/ies.v11n1p155>.

[9] Kanschat, Katharina and others, 'Fachglossar – Betriebliche Ausbildung Glossary of Vocational Training Terms', *Bundesministerium Für Bildung Und Forschung*, 2010, 1–58 <www.bmbf.de>

[10] Bogdan Bochenek and Zbigniew Ustrnul, 'Machine Learning in Weather Prediction and Climate Analyses—Applications and Perspectives', *Atmosphere*, 13.2 (2022), 180 <https://doi.org/10.3390/atmos13020180>.

[11] Oeben and Klumpp.

Indonesian vocational schools with a concentration of expertise in Food Crops and Horticulture Agribusiness (ATPH). [12, 13] The selection of documents is based on their relevance to agricultural vocational education. Supporting data in educational guidelines, syllabi, academic journals, research reports, and relevant articles from trusted publications are systematically selected to analyze the curriculum elements comprehensively.[14]

Data analysis techniques used content analysis methods to explore in-depth information from relevant documents. This analysis involved identifying themes, patterns, and relationships related to curriculum elements such as learning objectives, structures, pedagogical approaches, integration of theory and practice, industry engagement, use of technology, evaluation, and graduate sustainability. The analysis consisted of a document review, data coding into relevant themes, interpretation based on theoretical frameworks, and conclusions summarizing key findings and strategic recommendations.

Data validity is guaranteed through triangulation by integrating various data sources, such as official curriculum documents, academic literature, previous research reports, and supporting articles. This triangulation aims to increase the credibility of the analysis by comparing information from various perspectives to produce more objective and in-depth conclusions. Validity is also strengthened by conducting a critical review of the selected documents and literature to ensure that the data used is in the context and objectives of the research.

Finding and Discussion

Finding

The German education system is known for its well-organized structure, which includes different levels of education designed to meet the developmental needs of children, society, and the labour market. Early childhood education (Kindergarten) is intended for children aged 3–6 years and is optional. However, most families in Germany use Kindergarten as preparation for entering primary education (Grundschule). [15] Primary education lasts four years in most regions, but it is extended to six years in Berlin and Brandenburg. This difference in duration is due to the decentralization policy in the German education system, which gives autonomy to each state (Bundesland).[16] This policy is tailored to local needs but poses the challenge of incompletely uniform standards, which can impact differences in learning outcomes and student readiness for continuing secondary education. [17]

Next, the elementary level, the curriculum includes reading, writing, mathematics, music, art, sports, and ethics. After completing the Grundschule, students are directed to the secondary education track (Sekundarstufe I and II) based on academic achievement, ability, and teacher recommendations. The secondary education track consists of Hauptschule (focusing on practical skills), Realschule (a combination of theory and practice), Gymnasium (academic preparation for university with graduates obtaining the Abitur), and Gesamtschule (a flexible combination of the three tracks). [18] This system allows students to choose the track that best suits

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[12] Mohamad Joko Susilo, Junanah Junanah, and M Hajar Dewantoro, 'Comparison of Curriculum Implementation between Public and Private Schools Based on Adiwiyata', *Journal of Education and Learning (EduLearn)*, 15.4 (2021), 571–77 <https://doi.org/10.11591/edulearn.v15i4.20361>.

[13] Kurikulum, dan Asesmen Pendidikan Badan Standar, 'Keputusan Nomor 008/H/KR/2022 Tentang Capaian Pembelajaran Pada Pendidikan Anak Usia Dini, Jenjang Pendidikan Dasar, Dan Jenjang Pendidikan Menengah Pada Kurikulum Merdeka' (Indonesia, 2022).

[14] Sena Seçil Akpınarlı and Salih Levent Turan, 'An Examination of Reproduction and Development in Secondary School Biology Curricula: Türkiye and Germany', *Proceedings of International Conference on Research in Education and Science*, 9.1 (2023), 1854–65.

[15] Vlera Haxhiavdyli, 'German Education System', *Study in Germany*, 2024 <https://www.studying-in-germany.org/german-education-system/>.

[16] Haxhiavdyli.

[17] H. Döbert, E. Klieme, and W. Sroka, *Conditions of School Performance in Seven Countries*, 3rd edn (Waxmann Verlag, 2004).

[18] Haxhiavdyli.

their interests and abilities while allowing them to switch tracks if necessary.

Vocational education in Germany, involving Berufsschule and the Duale Ausbildung system, is vital in ensuring workforce readiness and low unemployment rates. The Duale Ausbildung system integrates theoretical learning in schools with practical industry training, allowing students to gain hands-on experience in the workplace. Companies participating in the program are key partners in training students while ensuring that the material taught aligns with the job market's needs.[19] Data from the Organisation for Economic Co-operation and Development (OECD) shows that the unemployment rate in Germany in May 2024 was around 3.3%, much lower than the average for European Union countries.[20] The contribution of vocational education to the low unemployment rate is very significant because graduates of this program not only have high technical skills but are also ready to compete in the global market. [21]

The German government continues to strive to reform the education system by implementing inclusion policies and digitalization of learning. Inclusion policies ensure that education is accessible to all groups in society, including children with special needs. [22] Meanwhile, digitalization is a priority, especially after the COVID-19 pandemic, as it introduces modern technology in the learning process to support flexibility and efficiency. [23] This initiative strengthens the competitiveness of the German education system amidst global changes. The effectiveness of the German education system is also reflected in its impact on social and economic mobility. Statistics show that vocational education graduates find employment faster than academic graduates, especially in the technical and industrial sectors. [24] Certification systems issued by professional bodies, such as chambers of commerce and industry associations, provide quality assurance and broad recognition of graduate competence.[25] With all these advantages, the education system in Germany contributes to the country's economic growth and provides more significant opportunities for students to improve their standard of living.

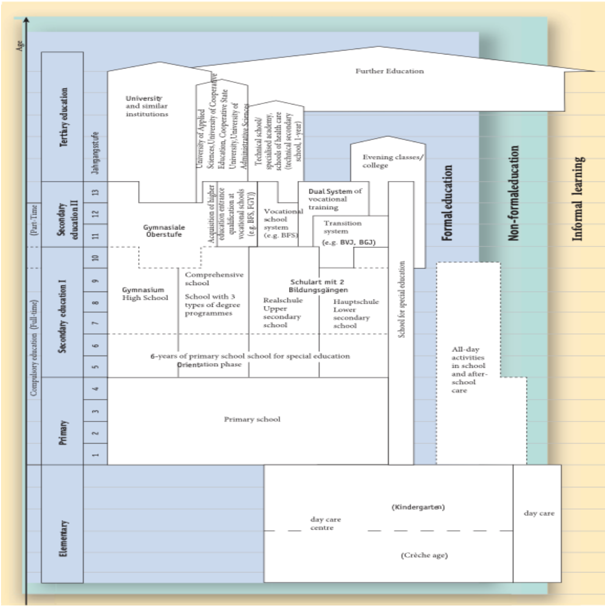

Figure 2. German Education System
Source: (Boutiuc-Kaiser, 2021)

[19] Boutiuc-Kaiser.

[20] OECD, *OECD Employment Outlook 2024 - Country Notes: Germany*, 2024 <https://www.oecd.org/en/publications/2024/06/oecd-employment-outlook-2024-country-notes_6910072b/germany_08ee101a.html#:~:text=In Germany%2C the unemployment rate,in late 2020%2Fearly 2021.>.

[21] Simone R Haasler, 'The German System of Vocational Education and Training: Challenges of Gender, Academisation and the Integration of Low-Achieving Youth', *Transfer: European Review of Labour and Research*, 26.1 (2020), 57–71 <https://doi.org/10.1177/1024258919898115>.

[22] Michel Knigge and David Kollosche, 'Inclusive Education in German Schools', in *Inclusive Mathematics Education* (Cham: Springer International Publishing, 2019), pp. 13–22 <https://doi.org/10.1007/978-3-030-11518-0_3>.

[23] Eucidio Pimenta Arruda, Suzana dos Santos Gomes, and Durcelina Pimenta Arruda, 'Digital Education in Germany: Policies, Teacher Perspectives, and Challenges in a Post-Pandemic World', *Forum for Education Studies*, 3.1 (2024), 1976 <https://doi.org/10.59400/fes1976>.

[24] Sabine Hoidn and Vít Šťastný, 'Labour Market Success of Initial Vocational Education and Training Graduates: A Comparative Study of Three Education Systems in Central Europe', *Journal of Vocational Education & Training*, 75.4 (2023), 629–53 <https://doi.org/10.1080/13636820.2021.1931946>.

[25] Jiří Braňka, *Understanding the Potential Impact of Skills Recognition Systems on Labour Markets: Research Report*, *Ilo* (Geneva, Switzerland: International Labour Organization, 2016).

Based on the general description of the education system in Germany, as shown in Figure 2, the research on the comparison of agricultural curricula, especially the concentration of agronomy between Germany and Indonesia, is of substantial relevance. The analysis focused on the curriculum structure, learning approaches, industry and technology integration, evaluation and certification systems, and graduate sustainability, which is expected to provide valuable insights for developing vocational education in Indonesia.

Based on the results shown in Table 1 below, a comparison of the agricultural vocational education systems between Germany and Indonesia shows fundamental differences in approach, focus, and integration with industry. The dual system in Germany is the main advantage, combining theory in vocational schools (Berufsschule) with intensive practice in partner companies. The program lasts 2–3.5 years, depending on the specialization taken, emphasizing the development of practical industry-based skills, the application of modern technologies such as smart farming, and close partnerships between schools and companies in designing the curriculum and providing training facilities.

Table 1. Comparison of German and Indonesian Learning System Policies

Aspects	Germany (Agronomy SMK/BBZ)	Indonesia (SMK/ATPH)
Main Approach	Dual system: a combination of theory in vocational schools and company practice.	Combining in-school learning with field practice (PKL) and entrepreneurship-based projects (Merdeka Curriculum).
Duration of Education	2-3.5 years, depending on the vocational program and specialization.	3 years for all vocational programs.
Main Focus	Developing industry-based practical skills and integrating modern technology such as Smart Farming.	Utilization of local resources, agribusiness development, and provision of farming-based entrepreneurship.
Learning Location	Vocational school (Berufsschule) for theory Partner companies for hands- on work practice.	• School for learning theory and basic skills. • Practical fieldwork in the local agricultural or agribusiness sector.
Speciality Subjects	Modern agronomy, agricultural technology, agricultural economics, and environmental sustainability.	Food crop agribusiness, digital- based farm marketing, and farm waste processing.
Learning Methods	Simulations and case studies. - Practice-based projects in companies. - Digital tools are used for agronomic analysis.	• Student creative projects • Competency-based practice. • Interdisciplinary approach to entrepreneurship and technology
Relationship with Industry	Close partnership between schools and companies to determine curriculum and provide training facilities.	Linkages with businesses through street vendors and local partnerships with small or medium-sized farms.
Certification	National vocational certificates are recognized by industry throughout Germany and the European Union.	National-based competency certificates through competency tests by professional certification bodies (LSP).
Assessment	A combination of theoretical exams, practical assessments in the company, and the final project.	Theoretical and practical exams, with an entrepreneurial project as one of the key parts of the evaluation.

In contrast, in Indonesia, agricultural vocational education combines theory in schools with field practice (PKL) and entrepreneurship-based projects by the Merdeka Curriculum. Education lasts for three years, focusing on utilizing local resources, agribusiness development, and provision of agricultural-based entrepreneurship. The adoption of modern technology, as in Germany, is still limited, although there are partnerships with the business world at the local level. Assessment in Germany includes a theory exam, practice in a company, and a final project, resulting in a national certificate recognized throughout Germany and the European Union. In contrast, in Indonesia, evaluation is carried out through a national-based competency test by the Professional Certification

Institute (LSP), including theory, practice, and entrepreneurship project tests.

Discussion

Curriculum Structure

The structure of the agronomy curriculum in Germany is designed to balance theory and practice, preparing graduates who are academically competent and skilled in the workplace (see Table 2). The Duale Ausbildung program provides a unique learning experience by combining theoretical learning at a vocational school (Berufsschule) with hands-on practice in a company or on a farm. Students spend 2–3 days per week at school studying theory, while the rest of the time is spent practising in the workplace.

Table 2. Agronomy Curriculum Structure

Curriculum Components	Subject/Module	Description	Time Proportion
Theory in School	Agronomy Basics	Basic principles of agronomy, including plant life cycle, photosynthesis, and soil management	20%
	Plant Recovery	Plant breeding techniques to increase yield and resistance to disease or weather extremes	10%
	Soil Science (Bodenkunde)	Study soil types, soil fertility, and how to sustainably manage soil	10%
	Plant Nutrient Management	Efficient fertilization, nutrient management, and irrigation techniques	10%
	Agricultural Ecology (Okologie)	Impacts of agricultural activities on the environment, including biodiversity management and friendly agricultural practices	10%
	Agricultural Technology	Use of equipment and technology to grow, harvest, and manage crops efficiently	10%
	Farm Business Economics and Management	Fundamentals of farm business, including costing, marketing farm produce, and financial management	10%
Practical (at training center/industry)	Plant Cultivation	Hands-on training in the field to plant, care for, and harvest crops according to modern agronomic standards	20%
	Use of Agricultural Machinery	Practical use and maintenance of heavy equipment such as tractors, planting tools, and harvesting tools	10%
	Land Management	Soil management techniques, including crop rotation, no- tillage planting, and irrigation	10%
Total			100%

Source: https://www.bibb.de/en/65925.php

Students study basic agronomy, agricultural technology, ecology, and farm management in the theory part, which covers 50–60% of the total educational time. This theoretical material is designed to provide a deep understanding of the basic concepts that underlie modern agronomy practices. On the other hand, hands-on practice takes up 40–50% and includes using heavy equipment, soil management, pest control, and crop rotation according to industry standards. These activities aim to develop technical skills relevant to the job market's needs.

The Duale Ausbildung program is considered important in agronomy education in Germany because it offers a close integration of theory and practice. This helps students understand the practical application of concepts learned in class and ensures that they are ready to work according to industry standards. In addition, this approach allows companies to directly contribute to shaping workforce competencies that match their needs, thereby increasing graduates' competitiveness in the global job market. With a systematic structure and focus on theory-practice balance, this curriculum effectively connects education and industry needs.

The advantage of this vocational education system structure lies in the continuous integration of theory and practice. During the first two years, students are directed to study basic training, including an in-depth introduction to the plant life cycle, cultivation techniques, and agricultural resource management. This initial stage is designed to provide students with a strong foundation of knowledge before moving on to the next level. In the final year, the focus of learning shifts to specializations, such as agribusiness management, modern agricultural technology, or environmental sustainability, according to industry interests and needs. This systematic stage not only allows students to master relevant technical skills but also helps them develop important soft skills, such as adaptability, critical thinking, and collaboration in a real work environment. This integration supports students' readiness to face challenges in the world of work with more confidence and competence.[26]

Unlike Germany, in the Merdeka Curriculum for the concentration of expertise in Food Crops and Horticulture Agribusiness (ATPH) in Indonesian Vocational High Schools (SMK), the proportion of theoretical and practical learning time varies according to class level and learning location. Basic vocational subjects related to the preparation of planting media have a composition of 90% theory and practice in schools and 10% practice in industry taught in grade X. The same applies to grade XI, with a proportion of 90% learning in schools and 10% in industry.

However, in grade XII, vocational learning focuses more on industrial work practice activities (PRAKERIN), with a time distribution of 50% in schools and 50% in industry. Technically, one theory session at school is equivalent to 1 lesson hour (JP) with a duration of 45 minutes, one practice session at school is equivalent to 3 JPs with a duration of 45 minutes per JP, and one practice session in industry is equivalent to 6 JPs with a duration of 60 minutes per JP (see Table 3).

When compared to the structure of the agronomy curriculum in Germany, it is clear that the vocational education system in Indonesia is still dominated by learning in schools, especially for grades X and XI (see Table 3). Although the proportion of practice is higher than theory, school facilities are often limited compared to the technology and methods available in the industry. This can hinder the development of students' competencies, which are more optimal if carried out in an industrial environment.[27] In contrast, in Germany, vocational learning is more integrated with practice in the industry. Students only receive about 10% theory in school, while the remaining 90% is done through practice in the industry during a three-year internship. Each stage of the internship is designed to develop different competencies, allowing students to master skills more quickly and relevant to the needs of the world of work.

Table 3. ATPH SMK Indonesia Curriculum Structure

CURRICULUM COMPONENTS	Element	Description	TIME PROPORTION		
			Theory in school	Practice in school	Practice in Industry
Class X	Preparation of planting media	Appropriate planting media are used for various conditions, such as wetlands, drylands, and potted planting, and innovative methods, such as hydroponics, aquaponics, and aeroponics. These planting media are also used in organic farming practices, conventionally and using modern technology.	30%	60%	10%

[26] Kanschat, Katharina and others.

[27] Supriyadi Teguh, 'Kebutuhan Guru Peminatan Kejuruan Dan Pemenuhannya Di Smk', *Jurnal Penelitian Kebijakan Pendidikan*, 12.1 (2019), 19–34 <https://doi.org/10.24832/jpkp.v12i1.259>.

CURRICULUM COMPONENTS	Element	Description	TIME PROPORTION		
			Theory in school	Practice in school	Practice in Industry
Class XI and Class XII	Seed preparation	Plant propagation includes vegetative methods such as cuttings, grafting, grafting tissue culture, and generative processes. These techniques are applied to food crops and horticulture using conventional approaches or modern technology.	30% 10%	60% 40%	Class XI 10% Class XII 50%
Class XI and Class XII	Planting	Plant cultivation stages include preparation, implementation, and embroidery, which are adjusted to the type of commodity. This process can be done using traditional methods or modern tools to increase efficiency and production results.	30% 10%	60% 40%	Class XI 10% Class XII 50%
Class XI and Class XII	Irrigation	Cultivation methods include various approaches for wetlands, drylands, annuals, perennials, and hydroponic, aquaponic, and aeroponic systems. Modern technology can support manual or mechanical implementation.	30% 10%	60% 40%	Class XI 10% Class XII 50%
Class XI and Class XII	Fertilization	Plant nutrition management includes using organic and/or inorganic fertilizers, either manually or mechanically. This system can be applied with conventional methods or modern technology to support optimal plant growth.	30% 10%	60% 40%	Class XI 10% Class XII 50%
Class XI and Class XII	Control of Plant Pest Organisms (OPT)	Pest and disease control is done through mechanical, biological, chemical, technical culture, biological methods, or integrated control systems. This process can be done with a conventional approach or using modern equipment to increase effectiveness.	30% 10%	60% 40%	Class XI 10% Class XII 50%
Class XI and Class XII	Special treatment	Plant maintenance involves giving growth hormones, hilling, pruning, and installing stakes, which are adjusted to the needs and conditions of the plants. This technique can be done conventionally or by utilizing modern technology.	30% 10%	60% 40%	Class XI 10% Class XII 50%
Class XI and Class XII	Harvest and post-harvest	Post-harvest stages include preparation, harvesting techniques, sorting, grouping, packaging, and labelling. To maintain the quality of agricultural products, this process can be done using conventional methods or modern technology.	30% 10%	60% 40%	Class XI 10% Class XII 50%
Class XI and Class XII	Management of agricultural waste	Sustainable agricultural practices include the production of green manure, compost, and botanical pesticides. Various methods are applied both conventionally and with modern technology to support the sustainability of the agricultural sector.	30% 10%	60% 40%	Class XI 10% Class XII 50%
Class XI and Class XII	Marketing	Aspects of agricultural management include communication, marketing techniques, both traditional and digital, business administration, and bookkeeping. This approach aims to improve the competitiveness and sustainability of agricultural businesses.	30% 10%	60% 40%	Class XI 10% Class XII 50%

Source : KSP SMKN 1 Pacet Cianjur (2024)

In addition, based on Table 4 and Table 5, the Merdeka Curriculum in Indonesia provides schools with flexibility in designing learning structures based on local needs and student conditions. In the concentration of expertise in Food Crops and Horticulture Agribusiness (ATPH), this curriculum covers various important elements, such as preparation of planting media, plant maintenance techniques, pest and disease control, and management of agricultural waste oriented towards sustainability. In addition, the Merdeka Curriculum also encourages integration between the development of local wisdom, such as the utilization of local natural resources, with global issues, including food security, adaptation to climate change, and the application of sustainable agricultural principles.[28]

Table 4. Elements of Agribusiness Subjects

Elements	Description
Planting media preparation	The use of appropriate media for plant cultivation on wetlands, drylands, and in pots, as well as various innovative methods such as hydroponics, aquaponics, and aeroponics. Growing media are also applied in organic farming practices, conventionally and using modern equipment.
Seedling preparation	These include vegetative methods such as cuttings, grafting, grafting, splicing, tissue culture, and generative methods. These techniques are applied to food and horticultural crops with conventional approaches and modern technology.
Planting	Includes the preparation, implementation, and replanting stages of crops adapted to the commodity type, using conventional methods and modern tools to increase efficiency and productivity.
Irrigation	Includes various approaches used in wetlands, drylands, annuals, and perennial crops, as well as cultivation methods of hydroponic, aquaponic, and aeroponic systems. These techniques can be done manually or mechanically by utilizing modern technology.
Fertilization	Includes using organic and/or inorganic fertilizers applied manually or mechanically in conventional systems or with modern tools to support plant growth.
Control of Plant Disturbing Organisms (OPT)	Through various methods, such as mechanical, biological, chemical, technical culture, biological, and integrated control systems. This process can be done conventionally or with the support of modern equipment to increase its effectiveness.
Special treatment	These include the application of growth hormones, fertilization, pruning, and installing stakes, which are adjusted to the plants' conditions and needs. This process can be done using conventional methods or modern technology.
Harvest and post- harvest	These include preparation, harvesting techniques, sorting, grouping, packaging, and product labeling. To maintain the quality of agricultural products, these stages are carried out both conventionally and using modern technology.
Agricultural waste management	Includes the production of green manure, compost, and plant- based pesticides, as well as various methods applied conventionally or with the help of modern technology to support sustainable agricultural practices.
Marketing	The approach includes aspects of communication, marketing techniques, both conventional and digital, business administration, and bookkeeping. It aims to improve the competitiveness and sustainability of agricultural businesses.

If examined further, based on Table 5, the concentration of the Independent Curriculum in the Food Crops and Horticulture Agribusiness (ATPH) balances theory and practice according to agricultural competency needs. In grade X, the focus of learning is the introduction of vocational basics such as agribusiness and horticulture. Theory dominates, while practice is limited to the early introduction of conventional cultivation methods and modern technology, especially in preparing planting media and plant propagation techniques.

Furthermore, in grades XI and XII, learning is directed at more complex vocational competencies, emphasizing practice in schools and industry. Grade XI is still dominated by practice in schools, while grade XII emphasizes industrial work practices (PRAKERIN) up to 50% of the

[28] Dinn Wahyudin and others, *Kajian Akademik Kurikulum Merdeka*, *Kemendikbud*, 2024 <https://kurikulum.kemdikbud.go.id/file/1711503412_manage_file.pdf>.

time. Students learn plant maintenance, harvesting, post-harvest, and sustainable agribusiness management by integrating modern technology to improve work readiness.

Table 5. Merdeka Curriculum Structure of ATPH Expertise Concentration

	MATA PELAJARAN	KELAS / ALOKASI JAM								
		X			XI			XII		
		1	2	P5	1	2	P5	1	2	P5
A. Kelompok Mata Pelajaran Umum										
1	Pendidikan Agama dan Budi Pekerti	2	2	0,5	2	2	0,5	3	-	0
2	Pendidikan Pancasila	2	2	0,5	2	2	0,5	2	-	-
3	Bahasa Indonesia	3	3	1	2	2	0,5	3	-	0
4	Pendidikan Jasmani, Olahraga dan Kesehatan	2	2	0,5	2	2	0,5	-	-	-
5	Sejarah	2	2	0,5	2	2	0,5	-		-
6	Seni Budaya	2	2	0,5	-	-	-	-		-
7	Muatan Lokal:** a. Bahasa Sunda	2	2	-	2	2	-	2		-
	Jumlah Jam	**15**	**15**	**3,5**	**12**	**12**	**2,5**	**10**	**0**	**0**
B. Kelompok Mata Pelajaran Kejuruan										
1	Matematika	3	3	1	3	3	0,5	2	-	-
2	Bahasa Inggris	3	3	1	2	2	1	2	-	-
3	Informatika	3	3	1	-		-	-	-	-
4	Proyek Ilmu Pengetahuan Alam dan Sosial	4	4	1,5	-		-	-	-	-
5	Kejuruan									
	a. Dasar-dasar Program Keahlian	12	12	-	-		-	-		-
	b. Konsentrasi Keahlian *** Produksi Tanaman Hias Produksi Tanaman Sayuran Produksi Tanaman Buah Produksi Tanaman Pangan	-		-	18	18	-	22	-	-
6	Proyek Kreatif dan Kewirausahaan	-		-	5	5	-	5	-	-
7	Praktik Kerja Lapangan ****	-		-	-	-	-	-	44	-
8	Mata Pelajaran Pilihan ***** Bahasa Jepang Kultur Jaringan Landscape and gardening Kuliner Web Design Tour Guide Pengolahan Tepung Public Area	-		-	4	4	-	6	-	-
	Jumlah Jam	**25**	**25**	**4,5**	**32**	**32**	**1,5**	**37**	**44**	**0**
TOTAL JAM		**40**	**40**	**8**	**44**	**44**	**4**	**47**	**44**	**0**
		48			**48**			**47**		

However, the duration of PKL for 3–6 months in grade XII is considered to provide less intensive practical experience compared to the dual system in Germany, where students do internships from the beginning of their education. However, the Merdeka Curriculum remains relevant by integrating digital technology innovation and entrepreneurship to prepare students to face the challenges of the global agribusiness sector. This approach is a strategic step to answer the workforce's needs and maintain the relevance of vocational education.

Learning Approach

The agronomy learning system in Germany uses a competency-based approach that aims to equip students with practical skills that can be directly applied in the workplace. One of its superior methods is the Duale Ausbildung Program, a dual education system that combines theoretical learning in vocational schools (Berufsschule) with direct practice in companies or agricultural fields. This program is designed to provide a holistic learning experience by directly involving students in real-world work situations, thereby bridging the gap between education and industry needs.

About the theoretical component, learning in schools is strengthened by active methods such as simulations, case studies, and field analysis to provide an in-depth understanding of agronomic concepts. Meanwhile, in the practical component, students work with partner companies to apply the theories they have learned. They are involved in operational activities such as using precision farming technology, namely sensor-based technology and GPS, to optimize land and crop management.[29] In addition, students also learn about digital-based agronomic data management using software such as Farm Management Information Systems (FMIS),[30] which allows them to analyze data related to weather patterns, plant nutrient needs, and crop rotation schedules.

As part of project-based learning, students are given independent tasks such as designing innovative crop rotation techniques to increase crop yields while maintaining soil fertility. This activity improves technical skills and hones students' analytical and innovative abilities to overcome complex agronomic challenges. With this integrative approach, Duale Ausbildung produces technically competent workers and professionals who can adapt to technological developments and sustainability principles in the agricultural sector.

Meanwhile, the learning approach adopted in the Merdeka Curriculum in Indonesia is starting to lead to innovation. The main strategies include

[29] Oeben and Klumpp.

[30] M. Reichardt and C. Jürgens, 'Adoption and Future Perspective of Precision Farming in Germany: Results of Several Surveys among Different Agricultural Target Groups', *Precision Agriculture*, 10.1 (2009), 73–94 <https://doi.org/10.1007/s11119-008-9101-1>.

project-based learning, problem-based learning, and teaching factories.[31] Through this method, students are invited to solve real problems in the agribusiness sector, such as managing agricultural waste or optimizing crop yields with simple technology.[32] However, implementing this method still faces challenges, especially in providing supporting facilities and competent human resources.[33]

Integration of Industry and Technology

The relationship between educational institutions and industry in Germany is very close, creating a synergistic collaboration in producing competent and work-ready graduates. Companies are actively designing the curriculum to align learning materials with industry needs. In addition, students receive hands-on training using advanced facilities and technologies, such as harvest automation and satellite data for land management. This training hones technical skills and familiarizes students with modern agricultural standard technologies. This collaboration ensures that graduates have relevant theoretical knowledge and practical experience, preparing them to face industry dynamics and technological changes (see Table 6 below).

Based on Table 6, technology plays a central role in agronomy education in Germany, making it a key pillar in preparing students for the challenges of modern agriculture. The training program uses precision farming devices, such as GPS for more efficient land management, and agronomic analysis software to design precise planting strategies. This technology helps increase productivity and prepares students to compete in the industrial era 4.0, where the ability to integrate data and digital technology is a key advantage. Additionally, this technology-based training enables students to understand the concept of sustainability in agriculture, making them more competitive in the global market.[34]

Table 6. Training Programs in Germany

1st Year Apprenticeship	2nd Year Apprenticeship	3rd Year Apprenticeship
• An introduction to fundamental farming practises and philosophies. • Studying crop cultivation methods, such as soil preparation, seeding, and plant maintenance. • Learning about feeding, checking on the health of, and handling animals.	• Gaining knowledge on how to operate and maintain specialised farm equipment. • Learning about the tools and methods used in precision agriculture. • Improving farm planning and resource management abilities.	• Increases understanding of managing a farm company, including budgeting, marketing tactics, and farm diversification • Taking part in planning and decision-making processes on the farm • Conducting agricultural experiments or research projects

Source: https://howtoabroad.com/farmer-ausbildung-in-germany-everything-you-need-to- know/#gsc.tab=0 (downloaded on December 17, 2024)

[31] Zahra Pitaloka Prasloranti, Masriam Bukit, and Shinta Maharani, 'EVALUASI PELAKSANAAN MODEL PEMBELAJARAN TEACHING FACTORY DI SMKN 1 CIBADAK', *EDUFORTECH*, 6.2 (2021) <https://doi.org/10.17509/edufortech.v6i2.39294>.

[32] E Ruban, N Rahmah, and I Fitria, 'Meningkatkan Hasil Belajar Siswa Dalam Agribisnis Tanaman Hias Dengan Model Pembelajaran PjBL Dan Pendekatan STEAM Di SMK Negeri 3 Maluku Tenggara', *Jurnal Pemikiran Dan Pengembangan Pembelajaran*, 4.1 (2022), 414–17 <http://www.ejournal-jp3.com/index.php/Pendidikan/article/view/240%0Ahttps://www.ejournal-jp3.com/index.php/Pendidikan/article/download/240/221>.

[33] Asriati, 'Agribisnis Tanaman Pangan Dan Hortikultura', *Repository.Pertanian.Go.Id*, 2018, 1–117 <http://repository.pertanian.go.id/bitstream/handle/123456789/15050/modul agb tanaman sayuran sem 3.pdf?sequence=1>.

[34] Milan Pozderac, Ty T. Casey, and Tracy Kitchel, 'Insights from Second Generation Agriculture Teachers on Career Choice and Identity', *Journal of Agricultural Education*, 63.1 (2022), 47–61 <https://doi.org/10.5032/jae.2022.01047>.

In Indonesia, technology integration in vocational education in agribusiness is still in its early stages (see Table 7). Most schools still use semi-automatic devices, such as irrigation and fertilization systems, while advanced technologies, such as those implemented in Germany, are rarely used. However, some schools have begun to adopt digital technology, such as agricultural marketing applications and online-based agribusiness management information systems. This step opens up opportunities for students to engage in digital agribusiness innovation, broaden their horizons, and provide learning more relevant to modern needs.

Strategic policy support from the government, improvement of teacher skills, and strengthening of partnerships with industry are needed to optimize this potential. The right policies can accelerate technological transformation in vocational education and encourage wider technology adoption in schools.[35] In addition, intensive training for teachers and students is needed to operate more complex technology.[36] With these steps, Indonesia has an excellent opportunity to accelerate technological acceleration in vocational education, especially in agribusiness.[37]

Table 7. Technology Integration in ATPH Vocational Education in Indonesia

Aspect	Implementation
Technology Semi-Automatic	Drip irrigation system, automatic fertilization tools
Digital Technology	Agricultural product marketing applications, online agribusiness management information systems
Modern IoT-Based Technology	Sensors for monitoring land conditions, IoT-based automatic devices
Digital Education System	E-learning for agribusiness theory, virtual simulation of cultivation practices

Source:
Gani & Baye (2018)[38]; Kurniawan et al. (2018)[39]; Musdaniati & Anggraeni (2018)[40]; Dwiyatno et al. (2022)[41]; Al-Hafiz et al. (2023)[42]; Ayanto & Pratama (2024)[43]

Evaluation and Certification

Vocational education evaluation in Germany involves three main components: theoretical exams, practical exercises, and a final project supervised by a professional body such as a chamber of commerce and industry. The final project often involves solving real-world problems like supply chain optimization or applying automation technology. Successful students receive an internationally recognized "Gesellenbrief" certification, ensuring that

[35] Wahyudin and others.

[36] Endang Mulyatiningsih, 'Analisis Potensi Dan Kendala Teacherpreuner Di SMK', *Jurnal Kependidikan*, 45.1 (2015), 62–75 <https://journal.uny.ac.id/index.php/jk/article/view/7186/6196>.

[37] Joessianto Eko Poetra and others, 'Dampak Pembelajaran Berbasis Proyek Dengan Otomatisasi Alat Pertanian Terhadap Keterampilan Teknis di SMK Nasional Dawarblandong', 1, 2024, 28–38.

[38] Abdul Gani and Wire Baye, 'Sistem Informasi Praktek Kerja Industri Pada SMK Islam Sirajul Huda Paok Dandak', *Jurnal Manajemen Informatika Dan Sistem Informasi*, 1.1 (2018), 52 <https://doi.org/10.36595/misi.v1i1.18>.

[39] D. Kurniawan, Y. Yaddarabullah, and G. Suprayitno, 'Implementasi Internet of Things Pada Sistem Irigasi Tetes Dalam Membantu Pemanfaatan Urban Farming', *The 7 Th University Research Colloquium*, 11.June (2018), 106–17.

[40] Ulfah Retno Musdaniati and Andian Ari Anggraeni, 'Pengembangan Video Pembelajaran Student Centered Learning Pembuatan Sirup Pada Mata Pelajaran Teknik Pengolahan Hasil Pertanian Di SMK Negeri 1 Pandak Bantul Yogyakarta', *E-Journal Student PEND. TEKNIK BOGA - S1*, 7.4 (2018), 1–12 <http://journal.student.uny.ac.id/ojs/index.php/boga/article/view/11622>.

[41] Saleh Dwiyatno and others, 'S Smart Agriculture Monitoring Penyiraman Tanaman Berbasis Internet of Things', *PROSISKO: Jurnal Pengembangan Riset Dan Observasi Sistem Komputer*, 9.1 (2022), 38–43 <https://doi.org/10.30656/prosisko.v9i1.4669>.

[42] Nofri Wandi Al-Hafiz and others, 'Pelatihan Pengenalan Perangkat Iot Bidang Pertanian Pada Smk Negeri 3 Teluk Kuantan', *BHAKTI NAGORI (Jurnal Pengabdian Kepada Masyarakat)*, 3.2 (2023), 221–27 <https://doi.org/10.36378/bhakti_nagori.v3i2.3396>.

[43] Aryanto and M. Herly Pratama, 'Pelatihan Implementasi IoT Untuk Monitoring Dan Otomasi Tanaman Lada Di SMK SMTI Bandar Lampung Dalam Mendukung Pertanian Berbasis Teknologi Training on IoT Implementation for Monitoring and Automation of Pepper Plants at SMK SMTI Bandar Lampung to Suppor', *Jurnal Masyarakat Mengabdi Nusantara*, 3.4 (2024), 31–42 <https://doi.org/https://doi.org/10.58374/jmmn.v3i4.281>.

graduates have competencies that meet global standards and are ready to compete in the international job market.[44]

On the other hand, vocational education evaluation in Indonesia involves theory exams, practical exercises, and an entrepreneurial project, among the important assessment elements.[45] This assessment is a formative, summative form organized internally by the school.[46] This project aims to motivate students to create solutions based on local needs, such as digital marketing or agricultural product innovation. Competency certification provided by the National Professional Certification Agency (BNSP) refers to national competency standards covered in the Indonesian National Qualifications Framework (KKNI).[47]

Although this evaluation approach is relevant to the local context, Indonesian certification is still limited nationally, so graduates need additional training to meet international standards. This is a major challenge in increasing graduates' competitiveness in the global market, especially given the need for a skilled workforce that can adapt to technology and market dynamics. Therefore, strategic steps to increase certification recognition through international partnerships and harmonization of global competency standards are necessary.

Graduate Outcomes and Sustainability

Agronomy graduates in Germany are prepared to become technically skilled professionals who adapt to the ever-evolving industry's needs. The dual education system ensures that students receive theoretical training at school and hands-on practice in agricultural companies. The focus on sustainability prepares graduates to face global challenges such as climate change and food security, with skills in precision farming, modern agribusiness, and sustainability principles. Most graduates pursue careers in the modern agricultural sector, while others continue their studies in agribusiness or agricultural technology to contribute to innovation.[48]

Graduates of the Independent Curriculum agribusiness program in Indonesia have basic skills relevant to local needs, such as crop management and digital-based agribusiness. The sustainability project-based curriculum develops skills to address global issues,[49] including climate change and resource efficiency. However, limitations in using advanced technology and industry involvement often require graduates to undergo additional training to compete globally. Strengthening cooperation with industry and broader adoption of digital technology will increase the competitiveness of Indonesian graduates in the global market.

Lastly, Table 8 shows a clearer picture of the differences and similarities between the agronomy curriculum in Germany and Indonesia based on the description of each aspect compared. A systematic comparison is carried out based on several main aspects that were previously described. These aspects include learning approaches, duration of education, curriculum structure, learning focus, industry involvement, use of technology, evaluation and certification, and graduate outcomes (see Table 8 below).

[44] Peter Kern and Martin Boehm, 'Agri-Trans : Transparency in Agricultural Vocational Training Design ':

[45] Ruli Setiyadi, Uus Kuswendi, and Muhammad Ghiyats Ristiana, 'Learning of Reading Comprehension through Reading Workshop in the Industry 4.0', *Mimbar Sekolah Dasar*, 6.2 (2019), 160 <https://doi.org/10.17509/mimbar-sd.v6i2.17397>.

[46] Gülşah Özdil, Fatma Merve Simsek, and Mehmet Nur Tuğluk, 'Comparison of Digital Assessment and Documentation Systems Used in the Early Childhood Education in Turkey, Germany and Spain', *Southeast Asia Early Childhood Journal*, 10.2 (2021), 1–15 <https://doi.org/10.37134/saecj.vol10.2.1.2021>.

[47] Badan Nasional Sertifikasi Profesi, 'Pedoman Pelaksanaan Sertifikasi Kompetensi Bagi Lulusan Sekolah Menengah Kejuruan (SMK)', 2017, pp. 1–9.

[48] Pozderac, Casey, and Kitchel.

[49] Farhan Hanif and Abdurrahman, 'Enhancing 21 St-Cetury Skills Through Project-Based Learning: Isights from Vocational Education in Egypt', *Jurnal Educative: Journal of Educational Studies*, 9.2 (2024), 92–103 <https://doi.org/https://doi.org/10.30983/educative.v9i2.8574>.

Table 8. Curriculum Comparison Analysis

Aspects	Germany	Indonesia
Education System	Dual System: A combination of theoretical learning at vocational schools and practical learning at companies or farms.	The dominance of theory at school with fieldwork practice (PKL) is limited in duration.
Duration of Education	3 years (on average), covering theory and practice simultaneously.	3 years at SMK, with 3-6 months of fieldwork practice.
Curriculum Structure	1. Theory: Agricultural technology, soil science, farm management. 2. Practice: Intensive internship in a farming company or business field.	1. Theory: Fundamentals of agronomy, agricultural technology, and entrepreneurship. 2. Practical: Shorter, focusing on introducing tools and methods.
Learning Focus	Competency-based, emphasizing practical skills, sustainable production management, and modern agricultural technology.	A combination of competencies and knowledge, focusing on basic and traditional agricultural production.
Technology and Innovation	Use of high technology such as smart farming, digitization of agricultural data, and automation.	Limited to essential technologies such as manual and semi-automated farming tools.
Industry Involvement	Close collaboration between schools, companies, and government. Industry plays an active role in practice and evaluation.	Industry cooperation exists but is uneven, and local industry involvement varies.
Competency Standards	Professional competencies based on the *National Qualifications Framework* (DQR).	Following the *Indonesian National Work Competency Standards* (SKKNI).
Evaluation and Certification	Practical and theory-based exams and certifications are nationally recognized by bodies such as the IHK (Chamber of Commerce and Industry).	Theoretical and practical exams, school-based certification, and national vocational exams.
Graduate Output	Graduates are ready to work with technical and managerial skills according to the needs of modern industry.	Graduates have a foundation of skills but often require additional industry training.
Development Sustainability	Focus on sustainable agriculture, soil conservation, and resource efficiency.	They are starting to be implemented, but most focus on land productivity.

Based on the comparison made in Table 8, Germany's agronomy education system has advantages in integrating theory and practice through Duale Ausbildung, with intensive and continuous industry involvement. This allows students to understand academic concepts and acquire practical skills relevant to the needs of the modern job market. The longer duration of education in Germany for practice (40-50% of study time) compared to Indonesia (3-6 months) provides advantages in building student competencies. Advanced technologies such as smart farming and digitalization of agronomy data are integral to training in Germany, reflecting their readiness to face the industrial era 4.0. In contrast, the education system in Indonesia is starting to move towards innovation by adopting approaches such as project-based learning to support the development of student competencies.[50]

From the evaluation side, the "Gesellenbrief" certification in Germany has international recognition, while the SKKNI-based certification in Indonesia is still limited to the national level, impacting graduates' competitiveness in the global market. This comparison shows that Germany excels in integrating theory, practice, technology, and industry involvement. At the same time, Indonesia has great potential to develop by utilizing local wisdom, strengthening industry partnerships, and increasing the adoption of modern technology.

Conclusion

Based on the content analysis of agricultural curricula in Germany and Indonesia, it was found

[50] Nurain Djafar, Jusna Ahmad, and Masra Latjompoh, 'Efektivitas Pengembangan Perangkat Pembelajaran Model Project Based Learning Dengan Pendekatan Stem Untuk Meningkatkan Keterampilan Proses Sains Peserta Didik', *Bioedukasi (Jurnal Pendidikan Biologi)*, 13.2 (2022), 200 <https://doi.org/10.24127/bioedukasi.v13i2.6348>.

that although the Indonesian curriculum has tried to approach German standards, there are still significant differences. The Indonesian curriculum focuses more on local needs, while Germany has integrated advanced technologies such as smart farming. The proportion of learning in Indonesia is 30% theory and 70% practice, but industry involvement in practice is minimal. As a result, Indonesian Agricultural Vocational School graduates have not fully met industry demands, especially regarding technical skills and modern technology. In contrast, in Germany, students gain direct experience in industry through the Duale Ausbildung system and international certification, such as Gesellenbrief, while Indonesian graduate certificates are only recognized nationally. To improve the competitiveness of graduates, Indonesia needs to expand cooperation with industry, develop structured internship programs, and improve the quality of competency certification to an international level.

Several strategic recommendations are suggested to improve agricultural education in Indonesia. First, the curriculum should be based on smart farming, integrating technologies such as IoT, modern irrigation, soil sensors, and drones. Second, the portion of industrial practice needs to be increased through Project-Based Learning that manages school land and marketing of agricultural products. Third, cooperation between the government, BNSP, and KADIN is needed to improve competency certification internationally. Fourth, career promotion that includes entrepreneurial opportunities and further education needs to be improved to encourage the younger generation to be involved in the agricultural sector. Fifth, the image of agriculture must be improved through promotion in the media that highlights economic potential and innovation. Sixth, further research is needed to evaluate the impact of Agricultural Vocational School graduates on food security, productivity, and sustainability. With these steps, agricultural education in Indonesia can produce competitive and professional graduates and contribute to global food security.

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