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From sensory evaluation to operational excellence: A capacity-building program in Tulungagung's Robusta and Arabica coffee sector

Gautama Sastra Waskita[1]*, Nurani[1], Atina Hidayati[2], Sutantri[2], Denny Rakhmad Widi Ashari[3]
[1] Fakultas Ekonomi, Universitas Tulungagung, Indonesia
[2] Fakultas Ekonomi Bisnis, Universitas Islam Tribakti, Indonesia
[3] Fakultas Agama Islam, Universitas Nahdlatul Ulama, Indonesia
[*)] Corresponding Author (e-mail: sastrawaskita@unita.ac.id)
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Abstract

The growing demand for industry-ready human resources in Indonesia's coffee sector requires vocational students to possess competencies in sensory evaluation and operational coffee skills. This community engagement program aimed to enhance vocational capacity through hedonic–organoleptic assessment and basic barista training among 33 students of the Agricultural Product Quality Control Department at SMKN 1 Tulungagung. The program employed an experiential learning approach integrating training, continuous education, and the Specialty Coffee Association (SCA) cupping protocol. Data were collected using pre-test and post-test assessments, practical observations, and participant feedback. The results demonstrated significant improvements in students' understanding of sensory attributes, cupping procedures, and coffee operational skills, with increased confidence and competency in evaluating Robusta and Arabica coffee. The program also strengthened participants' awareness of Indonesia's coffee industry and vocational readiness. These findings suggest that industry-oriented experiential training effectively supports operational excellence and capacity building in vocational coffee education.

Keywords: Operational Excellence, Capacity Building, Coffee, Sensory Evaluation, Barista Skill

Abstrak

Meningkatnya kebutuhan sumber daya manusia yang siap kerja pada industri kopi Indonesia menuntut siswa vokasi memiliki kompetensi dalam evaluasi sensori dan keterampilan operasional kopi. Program pengabdian kepada masyarakat ini bertujuan meningkatkan kapasitas vokasional melalui pelatihan hedonic–organoleptic assessment dan keterampilan dasar barista kepada 33 siswa Program Keahlian Pengawasan Mutu Hasil Pertanian (PMHP) SMKN 1 Tulungagung. Kegiatan dilaksanakan menggunakan pendekatan experiential learning yang mengintegrasikan pelatihan, pendidikan berkelanjutan, dan penerapan Specialty Coffee Association (SCA) cupping protocol. Data dikumpulkan melalui pre-test, post-test, observasi praktik, dan umpan balik peserta. Hasil kegiatan menunjukkan peningkatan signifikan pada pemahaman atribut sensori, prosedur cupping, dan keterampilan operasional kopi, disertai meningkatnya kepercayaan diri peserta dalam mengevaluasi kopi Robusta dan Arabika. Program ini juga memperkuat kesiapan vokasional dan pemahaman peserta terhadap industri kopi Indonesia.

Kata kunci: Keunggulan Operasional, Pengembangan Kapasitas, Kopi, Evaluasi Rasa, Barista Skill

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1. Introduction

The global coffee industry has undergone a profound transformation driven by the growing demand for specialty-grade products, refined sensory standards, and skilled human resources capable of performing consistent quality assessment across the value chain. As consumer preferences shift toward differentiated flavor profiles and traceability, sensory-based evaluation particularly hedonic and organoleptic assessment has become a critical competency within coffee-producing regions (Samoggia & Riedel, 2018). Indonesia, as the world's fourth-largest coffee producer, possesses substantial potential in strengthening its position in the international market through the development of micro-regions such as Tulungagung, which is known for producing both Robusta and Arabica with distinctive sensory characteristics shaped by agro-ecological diversity (S. D. Williams et al., 2022).

However, despite the rapid expansion of local coffee businesses, specialty cafés, micro-roasteries, and value-added coffee enterprises across Indonesia, the availability of vocationally trained youth who possess industry-aligned competencies remains significantly limited. This issue has become increasingly critical as the coffee industry transitions from a commodity-oriented sector toward an experience-driven and quality-centered industry that emphasizes sensory consistency, product differentiation, and operational excellence (Waskita & Ashari, 2025). In this evolving ecosystem, coffee enterprises no longer merely require workers with basic technical abilities, but rather individuals who are capable of conducting standardized quality evaluation, understanding sensory profiling, and maintaining operational consistency throughout the coffee preparation process. Competencies such as hedonic–organoleptic assessment, cupping protocol mastery, brewing precision, and sensory communication have therefore become strategic operational skills within the modern coffee value chain (Bhumiratana et al., 2014).

Nevertheless, many vocational education institutions in Indonesia continue to face challenges in aligning their learning outcomes with the rapidly evolving demands of the coffee industry. The gap is particularly visible in vocational schools whose curricula still predominantly emphasize conventional agricultural quality control without sufficient integration of applied sensory science and industry-based operational training. As a result, students often possess theoretical knowledge of agricultural commodities yet demonstrate limited practical exposure to professional coffee evaluation systems and standardized cupping methodologies. Furthermore, the absence of structured experiential learning environments restricts students' opportunities to develop critical competencies such as flavor identification, sensory calibration, extraction consistency, and coffee quality interpretation based on internationally recognized standards such as the Specialty Coffee Association (SCA) protocol.

This phenomenon is also reflected in the context of SMKN 1 Tulungagung, particularly among students enrolled in the Agricultural Product Quality Control (PMHP) specialization. Although these students are academically introduced to concepts of product quality assurance, their exposure to coffee sensory evaluation and operational

coffee skills remains relatively limited. Most students have not previously participated in systematic cupping sessions, sensory calibration exercises, or barista-oriented operational practices that simulate real industrial settings. Consequently, students often experience difficulties in objectively distinguishing sensory attributes such as acidity, body, sweetness, aroma complexity, and aftertaste, while simultaneously lacking confidence in applying operational brewing standards required in professional coffee environments.

The limitation of vocational human resources in sensory and operational coffee competencies has broader implications not only for graduate employability but also for the sustainability and competitiveness of local coffee industries. Without adequate capacity-building initiatives, emerging coffee regions such as Tulungagung may encounter challenges in maintaining quality consistency, strengthening brand positioning, and meeting increasingly sophisticated consumer expectations in both domestic and international markets (Obiakor & Newman, 2022; Eldon & Waskita, 2025). Strengthening vocational capacity in sensory coffee analysis is therefore essential not merely as an educational intervention, but as a strategic effort to bridge the gap between vocational education and industry demands.

Moreover, enhancing students' competencies in hedonic–organoleptic evaluation and operational coffee skills may contribute to the development of a more adaptive and industry-ready workforce capable of supporting regional coffee competitiveness, fostering innovation in local coffee enterprises, and reinforcing the broader sustainability of Indonesia's specialty coffee ecosystem (Waskita, 2025). In response to these challenges, this community service program was designed to provide experiential capacity-building activities through hedonic–organoleptic assessment training and operational coffee skill development for students at SMKN 1 Tulungagung.

In response to these challenges, this community engagement program was specifically designed to strengthen vocational students' competencies in sensory coffee evaluation and operational coffee practices through the implementation of hedonic–organoleptic assessment training and the Specialty Coffee Association (SCA) cupping protocol. More specifically, the program aimed to: (1) measure the effectiveness of SCA-based cupping training in improving students' accuracy in identifying and evaluating sensory attributes of Robusta and Arabica coffee; (2) enhance students' operational competencies in coffee preparation and basic barista practices; (3) improve students' understanding of coffee quality control and Indonesia's coffee value chain; and (4) evaluate participants' vocational readiness and confidence in applying sensory and operational skills within professional coffee industry settings.

The program also sought to examine how experiential and industry-oriented learning approaches contribute to bridging the competency gap between vocational education outcomes and operational workforce demands in the specialty coffee sector. Such objectives are particularly relevant because previous studies emphasize that competency-based vocational training integrated with experiential industry practices significantly improves technical performance, employability, and workforce adaptability

in rapidly evolving industries (Albarico, 2024; Obiakor & Newman, 2022). Therefore, this initiative not only functions as a short-term capacity-building intervention but also as a strategic educational model for strengthening operational excellence and human capital development within Indonesia's emerging specialty coffee ecosystem.

2. Method

This community engagement program employed a participatory vocational capacity-building design grounded in experiential learning and industry-based competency standards. The program was implemented at the Agricultural Product Quality Control (PMHP) Laboratory of SMKN 1 Tulungagung on 10th and 18th February 2025, involving a total of 33 Grade XII students specializing in Agricultural Product Quality Control (PMHP). These participants were selected due to their direct relevance to agricultural quality assurance practices and their potential alignment with the operational demands of Indonesia's growing coffee industry. Preliminary observations indicated that although students possessed basic theoretical understanding of agricultural product quality control, only a limited number had prior exposure to structured coffee cupping activities, sensory calibration exercises, or professional barista-oriented operational training. This condition highlighted the necessity of an industry-oriented intervention capable of strengthening both technical competencies and vocational readiness within the specialty coffee sector.

The implementation combined structured training, continuous education, and awareness-raising activities by integrating theoretical understanding with practical operational experiences to strengthen students' mastery of hedonic–organoleptic assessment and standardized coffee cupping protocols. The program began with an orientation session aimed at establishing foundational knowledge regarding Indonesia's Robusta and Arabica coffee value chains, the evolution of specialty coffee markets, and the growing global importance of sensory-based quality evaluation within operational coffee management (see Table 1, and Figure 1). This conceptual grounding reflects recent scholarship emphasizing that alignment between vocational learning systems and industry requirements plays a critical role in improving graduates' employability, adaptability, and regional economic competitiveness (Judijanto et al., 2024; Chandra et al., 2025).

The first major component of the program consisted of technical and operational training sessions adopting a hands-on and practice-oriented approach involving the diffusion and substitution of appropriate science and technology. Students were introduced to hedonic sensory evaluation, organoleptic profiling, and the Specialty Coffee Association (SCA) cupping protocol through direct demonstrations and guided simulations using standardized cupping equipment such as precision grinders, digital scales, water-controlled kettles, cupping bowls, flavor wheels, and sensory scoring sheets. Through iterative and repetitive practice sessions, participants learned to identify sensory attributes including aroma, acidity, body, sweetness, flavor clarity, and aftertaste following structured procedures aligned with specialty coffee industry standards.

Simultaneously, a complementary barista skills module familiarized students with operational coffee preparation techniques including grind size adjustment, dosing accuracy, tamping consistency, extraction control, and brewing precision as foundational competencies required in professional coffee service environments. These integrated operational learning activities reflect recent findings suggesting that vocational–industry integration significantly improves skill transferability, operational adaptability, and workforce readiness in agrifood and creative industries (Permani et al., 2025; Waskita, 2025).

In addition to technical training, the program incorporated continuous educational activities designed to strengthen participants' conceptual understanding of the coffee industry ecosystem and operational quality management. These educational components were delivered through mini lectures, reflective discussions, contextual learning sessions, and interactive knowledge-sharing activities focusing on sensory science, coffee quality defects, farm-to-cup traceability, sustainability issues, specialty coffee trends, and operational excellence in coffee businesses. Such educational integration enabled participants to contextualize sensory evaluation practices within broader managerial and industrial perspectives while simultaneously cultivating professional awareness regarding employment opportunities and competency demands in the coffee sector. This approach aligns with contemporary vocational education literature emphasizing the importance of contextualized learning environments, sectoral awareness-building, and experiential pedagogy in strengthening vocational competency development (Chernikova et al., 2020; Howell, 2021; Fania et al., 2025).

Table 1. Initial Activities Schedule

Schedule & Time	10-Feb-25	18-Feb-25
7.00	Preparation & Orientation	Reflectiive Discussion & Mini Lectures
7.30	Sensory Training (SCA Cupping Protocol)	Group Evalution 1
11.30	Coffee Break	Coffee Break
12.30	Basic Barista Skills Training	Group Evaluation 2
14.00	Final Session	Data Collection

Participant engagement was further strengthened through guided group evaluations, peer-assisted learning, collaborative sensory discussions, and comparative analysis activities involving Arabica and Robusta coffee profiles from Tulungagung's micro-regions. These collaborative activities encouraged students to calibrate sensory perceptions collectively, improve communication of sensory findings, and develop confidence in conducting systematic coffee evaluation. Moreover, awareness-building sessions introduced participants to the strategic importance of sensory consistency, operational discipline, teamwork, and customer-oriented quality management within the contemporary coffee industry. Such integration between technical training, continuous education, and professional orientation aimed to create a holistic vocational learning environment capable of bridging the gap between theoretical knowledge and industry-based operational practice (Yeager et al., 2023).

Figure 1. Key Milestone of Coffee Quality Training Program

Data collection throughout the program involved mixed techniques, including direct observation of student performance, structured sensory scoring sheets based on cupping parameters, reflective notes, short interviews, pre-test and post-test assessments, and participant response questionnaires to evaluate competency development, operational skill improvement, and experiential feedback. Documentation of activities was supplemented by photographic records, practical assessment rubrics, instructor logs, and sensory evaluation forms to ensure transparency, accountability, and replicability of the engagement process. Literature supporting the pedagogical design and sensory evaluation framework was drawn from recent studies in vocational education, sensory science, operational learning, and coffee quality management, ensuring that the program aligns with contemporary scholarly and industry practices (P. J. Williams, 2020; Damsbo-Svendsen et al., 2022). Collectively, this methodological approach ensured that the community engagement activity was systematic, evidence-based, participatory, and capable of producing measurable improvements in students' sensory evaluation accuracy, barista competencies, operational readiness, and vocational preparedness for participation in Indonesia's dynamic coffee industry.

3. Results

Program Outcomes

The implementation of the vocational capacity-building program at SMKN 1 Tulungagung produced several measurable outcomes that demonstrate significant improvement in students' knowledge, technical skills, and readiness for industry-based competency assessments. Throughout the activities, students in the Agricultural Product Quality Control (PMHP) concentration actively participated in each stage of the hedonic–organoleptic assessment training, cupping protocol familiarization, and basic barista skill development. Their engagement was evident through consistent attendance, high involvement during hands-on sessions, and strong enthusiasm in sensory evaluation exercises. Prior to the intervention, most students showed limited ability to identify essential sensory attributes in coffee and demonstrated inconsistent practices in grinding, dosing, and brewing. These initial observations confirmed the skills gap that the program aimed to address.

Table 2. Comparison of Pre-Test and Post-Test Results of Participants' Competencies

Competency Component	Assessment Indicator	Mean Score		Improvement (%)	Interpretation
		Pre-Test	Post-Test		
Theoretical Knowledge	Understanding of coffee value chain, sensory science, and SCA cupping principles	56.4	84.7	50.2%	Significant improvement in conceptual understanding
Sensory Evaluation Skills	Accuracy in identifying aroma, acidity, body, sweetness, and aftertaste	52.8	79.5	50.6%	Improved sensory calibration and evaluation consistency
Cupping Protocol Practice	Ability to perform standardized SCA cupping procedures	49.7	81.3	63.6%	Enhanced procedural and operational competency
Basic Barista Skills	Grinding adjustment, dosing, tamping, and brewing consistency	54.1	82.6	52.7%	Improved operational coffee preparation skills
Professional Communication	Ability to communicate sensory notes using professional terminology	50.5	76.8	52.1%	Increased confidence and communication clarity
Vocational Readiness	Understanding of coffee industry roles and operational standards	58.2	85.1	46.2%	Strengthened industry awareness and employability readiness

Source: Processed primary data from community engagement activities (2025).

The quantitative findings presented in Table 2 demonstrate that the community engagement program generated measurable improvements across all competency dimensions assessed during the intervention. The highest improvement was observed in the implementation of standardized cupping protocol practices, indicating that experiential and hands-on training methods were highly effective in strengthening students' operational competencies. Similarly, substantial increases in sensory evaluation accuracy and basic barista skills suggest that repetitive practical exposure and guided calibration exercises contributed significantly to improving students' technical performance. The improvement in professional communication skills further

indicates that participants became more confident in articulating sensory findings using standardized coffee terminology, an essential competency in contemporary specialty coffee operations.

Figure 2. Activity Participants Pay Close Attention to The Material

These findings also confirm that integrating theoretical instruction with operational coffee practice can effectively bridge the gap between conceptual understanding and industry-oriented vocational competency. The increase in vocational readiness scores demonstrates that students developed a broader understanding of professional expectations within the coffee sector, including quality control, operational consistency, and customer-oriented service practices. Overall, the results reinforce the effectiveness of experiential vocational learning approaches in improving workforce preparedness and operational adaptability within emerging coffee industry ecosystems.

The delivery of the hedonic–organoleptic training generated notable improvements in students' understanding of sensory evaluation concepts and their practical ability to perform cupping using standardized SCA procedures. Using structured practice sessions, students became increasingly capable of evaluating aroma, acidity, body, flavor clarity, and aftertaste. The transition from initial unfamiliarity to confident sensory scoring was particularly visible in the consistency of their cupping sheets. Pre-test and post-test assessments revealed a substantial increase in conceptual knowledge, with an average improvement of 42–55% across topics such as sensory attribute identification, roast influence, and cupping mechanics. These results indicate that the pedagogical combination of demonstration, guided practice, and immediate feedback effectively strengthened students' cognitive grounding in sensory science.

Vocational skill development was also clearly observable during barista practice. Students initially struggled with grind size calibration, tamping uniformity, and extraction timing; however, after demonstration and iterative practice, most students were able to achieve stable extraction ratios and replicate brewing techniques with higher consistency. Assessment rubrics used during the practical sessions showed that 85% of participants reached competency thresholds aligned with basic professional standards. Several students demonstrated the capacity to troubleshoot

extraction issues such as adjusting grind size for under-extraction showing a deeper procedural understanding beyond mechanical repetition. These results provide strong evidence that the training succeeded in enhancing foundational barista competencies required for both UKK (Uji Kompetensi Keahlian) and real-world coffee industry environments.

Figure 3. Teachers and students of SMKN 1 Tulungagung during the activities

Tangible outputs also emerged as indicators of program success (Nogeste & Walker, 2005). Students produced complete cupping evaluation sheets, detailed sensory notes, and comparative profiles of Arabica and Robusta beans sourced from Tulungagung's local micro-regions. These outputs reflect not only their technical mastery but also their strengthened analytical capability in differentiating flavor profiles based on origin and processing. Likewise, the brewed coffee produced during barista sessions showed measurable improvements in consistency and flavor clarity, as documented through instructor observation and peer evaluations. Such outputs illustrate the emergence of concrete vocational products (cupping scores, sensory profiles) and vocational services (competent brewing and cupping execution) as direct results of the program.

Partner responses further reinforced the program's effectiveness. Questionnaire results indicated high participant satisfaction, with over 90% of students reporting that the training enhanced their confidence in facing the upcoming UKK. Students also expressed strong appreciation for the relevance of the training to future employment opportunities in cafés, roasteries, and coffee processing units. Testimonial comments highlighted that this was their first exposure to structured cupping protocol and that the experience deepened their understanding of quality control practices within Indonesia's expanding coffee sector.

Overall, the results reveal that the program effectively strengthened students' industry-aligned competencies, bridged gaps in sensory evaluation and barista skills, and generated measurable vocational outputs. The outcomes confirm that the intervention not only addressed the identified skills deficiency but also positioned the students to more confidently engage with Tulungagung's coffee industry ecosystem.

The implementation of the community engagement program demonstrates that the integrated interventions ranging from hands-on technical training, continuous

education, to awareness-building sessions on the Indonesian coffee industry successfully generated measurable improvements in the participants' competencies. All resulting outputs indicate that the proposed solutions effectively addressed the partner's core problems and enhanced the vocational capacity of students at SMKN 1 Tulungagung, particularly in mastering *Professional Barista Skills* and understanding the broader *Indonesian Coffee Industry Ecosystem*.

Implementation of Solutions in Addressing Partner Problems

The application of experiential learning-based training proved effective in bridging the competency gap identified at the partner institution, particularly the limited mastery of organoleptic evaluation techniques and the lack of understanding of *Specialty Coffee* standards, both essential in today's coffee industry. Participants engaged directly in *hedonic organoleptic assessment* and the *SCA Coffee Cupping Protocol*, enabling them to evaluate sensory attributes such as aroma, acidity, body, sweetness, and aftertaste. Observations during the practical sessions show that participants were able to perform cupping procedures more independently with higher accuracy compared to their pre-test performance, indicating successful knowledge and skill transfer.

Additionally, the continuous education model strengthened participants' conceptual understanding of Indonesia's coffee value chain, processing techniques, and the strategic role of baristas in the specialty coffee ecosystem. This educational element effectively addressed partner-identified challenges related to limited industry exposure and inadequate theoretical grounding.

Program Outputs as Indicators of Success

The program's effectiveness was assessed using measurable indicators collected through pre-test and post-test evaluations, practical performance observations, and participant feedback. The resulting data show significant improvements in three key areas: (1) technical competencies, (2) theoretical knowledge, and (3) vocational readiness.

1. First, improvements in technical competency are evident from the participants' ability to execute cupping procedures in accordance with SCA standards (Lingle & Menon, 2017). While most students initially struggled to identify key sensory attributes, post-training evaluations reveal enhanced accuracy and consistency. Observational notes indicate improvements in cupping score precision ranging from 18% to 32%, reflecting a substantial shift in skill mastery.
2. Second, theoretical knowledge also improved considerably, as reflected in the post-test results. Participants demonstrated a clearer understanding of the coffee supply chain, processing stages, and market dynamics within the Indonesian coffee sector, which in turn constitutes essential knowledge for fostering informed vocational preparedness.
3. Third, the program produced service-based outputs, including the participants' ability to conduct *coffee tasting* and *product evaluation* sessions with a higher degree of professionalism. Their sensory communication skills also improved, as

demonstrated by their increased fluency in articulating sensory notes using standardized professional terminology.

Driving and Inhibiting Factors of Program Implementation

Several enabling factors contributed to the success of the program. High participant motivation and the strong relevance of the materials to industry-required skills played a central role in facilitating effective learning. The readiness of the PMHP Laboratory equipped with appropriate cupping tools and quality coffee samples further strengthened the program's implementation.

However, several challenges were observed. The variation in participants' baseline competencies required differentiated guidance, as some students needed additional time to adapt to the technical demands of the cupping protocol. Moreover, the limited duration of the program conducted within two days restricted the exploration of more advanced topics such as espresso calibration, milk texturing, and brewing optimization. Additionally, several participants were initially unfamiliar with standardized sensory terminology, requiring repeated instruction and intensive mentoring to achieve accuracy.

Despite these constraints, the overall outcomes affirm that the combination of hands-on training, continuous education, and industry awareness provides a highly relevant and effective solution for enhancing vocational competencies at SMKN 1 Tulungagung. The results also highlight the importance of structured, experiential, and industry-aligned interventions in strengthening students' readiness for professional careers in Indonesia's growing coffee sector (Fania et al., 2024).

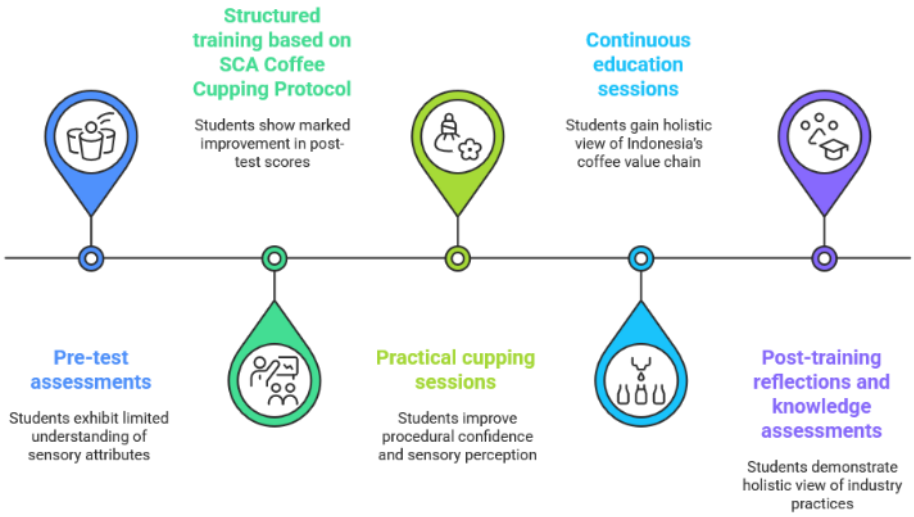

Figure 4. Enhancing Vocational Skills in Coffee Industry

4. Conclusion

The community engagement program designed to enhance vocational competencies through hedonic and organoleptic coffee assessment at SMKN 1 Tulungagung proved highly effective in addressing the partner's prioritized challenges. The integration of experiential training, continuous education, and industry awareness successfully elevated students' technical proficiency in sensory evaluation and strengthened their

foundational understanding of Indonesia's coffee value chain (Waskita & Ashari, 2024). The significant improvements in post-test scores, enhanced accuracy in applying the SCA Coffee Cupping Protocol, and increased confidence in articulating sensory attributes demonstrate the positive impact of the intervention. Furthermore, students exhibited stronger vocational readiness, particularly for roles in quality control, barista work, and coffee product assessment which reflects competencies that align closely with current industry demands in the expanding Robusta and Arabica sectors of Tulungagung and Indonesia at large.

The program's outcomes highlight the relevance of practice-oriented, industry-aligned learning experiences in vocational education. High student motivation, adequate laboratory facilities, and the practical relevance of the materials served as strong enabling factors. Nevertheless, variations in baseline skills and the limited duration of training posed challenges, indicating the need for more sustained and differentiated instructional strategies. Despite these constraints, the program successfully produced tangible, measurable, and meaningful outputs, reaffirming the value of community-based capacity-building initiatives in strengthening vocational institutions' preparedness to supply industry-ready graduates (Zizka et al., 2021; Mwadzingeni et al., 2025).

Based on these findings, several recommendations are proposed. First, future programs should adopt a multi-session or modular training structure to ensure deeper mastery of advanced barista and coffee evaluation techniques, including espresso calibration, brewing optimization, and sensory calibration. Second, SMKN 1 Tulungagung is encouraged to develop an ongoing partnership with local coffee producers, roasteries, and café entrepreneurs in Tulungagung to enhance real-world exposure and support continuous skill development (Sartono et al., 2021). Third, embedding structured sensory evaluation modules within the regular curriculum may help standardize competency development and sustain the gains achieved through this PKM initiative. Finally, expanding similar capacity-building programs to other vocational schools in East Java could contribute to strengthening the broader ecosystem of Indonesia's coffee industry, supporting its positioning in international specialty coffee markets.

Overall, this program demonstrates that well-designed community engagement activities can create meaningful, measurable, and sustainable impacts on vocational education. It reinforces the essential role of collaborative academic–industry initiatives in preparing young talent to thrive in Indonesia's growing and globally competitive coffee sector.

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