

Assessment of Vocational High School Tissue Culture Laboratory Readiness for Learning and Entrepreneurship: A Descriptive Study of Infrastructure and Management Standards

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Abstract: This research evaluates the readiness of the tissue culture laboratory at SMK Negeri 1 Pandak using an observation instrument of laboratory preparedness. This study focused on the laboratory infrastructure and management system as the primary object of observation in seven aspects. The instrument's validation was conducted by two Expert of Tissue Culture experts to yield Aiken's V validity coefficients for the seven aspects of laboratory readiness observation instrument ranging from 0.585 to 0.661, indicating that the instrument is valid. Observations of the tissue culture laboratory's readiness also revealed an average total readiness percentage of 76.72%, with the infrastructure (84.61%), facilities (85.84%), and administration (85.71%) aspects categorized as "Very Ready". The occupational health and safety (70%), learning process support (80%), and entrepreneurship development (68.42%) aspects are in the "Ready" category. The laboratory dynamics aspect (62.5%) showed a "Less Ready" category, thus requiring special attention. This research confirms the validity of the instrument and provides an overview of the tissue culture laboratory's readiness, and it can be used to enhance the quality and effectiveness of tissue culture laboratories in vocational agriculture schools. In addition, this result contributes as a strategic evaluation model in the management of vocational education laboratories and provides concrete recommendations for the development of entrepreneurship-based science education through the optimization of facilities and standardized management systems.

Keywords: Availability; Laboratory; Plant tissue culture

Introduction

Tissue culture technology can significantly contribute to enhancing plant productivity and quality in the agricultural sector. With its ability to improve agricultural productivity and quality, tissue culture technology has become a primary factor in raising the living standards of communities (Wanyama, 2015). This technique is widely used in research on plant development processes. It allows for the propagation of a large number of plants in a relatively short time (El-Sherif, 2019) and produces genetically uniform plants

(Bednarek & Orłowska, 2020) By providing appropriate environmental conditions, such as nutrients, growth hormones, and optimal temperature, plant cells can be induced to divide and differentiate into new tissues or organs (Bidabadi & Jain, 2020). Tissue culture plays a crucial role in agriculture, plantations, and horticulture, enabling the mass production of plant seedlings in a short time to meet increasing market demands (Tegen & Mohammed, 2016). This technique also accelerates the propagation of superior plants with desirable traits, such as disease resistance, high productivity, and good fruit quality (Zuzarte et al., 2024). Plants derived from tissue

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culture are generally disease-free because they are grown under sterile conditions (Zhao et al., 2023), and this technique also forms the basis of plant genetic engineering, such as the production of transgenic plants (De Filippis, 2014).

A tissue culture laboratory is a core facility in vocational schools with agriculture, plantation, or horticulture departments (Andriani & Heriansyah, 2021; Nasir & Mayasri, 2023), used for learning practices and students' entrepreneurship development (Rizki et al., 2021). As a window to biotechnology, this laboratory facilitates experiments and an in-depth understanding of plant growth (Harahap et al., 2020). However, many vocational schools do not yet have adequate tissue culture laboratories or have not utilized them optimally (Hasrawati et al., 2022). Assessing the readiness of these laboratories is important because it influences the quality of learning and students' work readiness. Common problems encountered include a lack of equipment, materials, and human resources (Sucahyo et al., 2023), as well as the non-fulfillment of national Standard Operating Procedures (SOP) (Prasetyo, 2021).

SMK Negeri 1 Pandak is one example of a vocational school that has strived to improve the quality of education through the development of a tissue culture laboratory to support the learning process of students in the Plant Seed Agribusiness (APT) department. However, research on the readiness of tissue culture laboratories in vocational schools needs to be conducted to determine the progress of development or the current conditions and identify the factors that influence them (Zahara, 2017), in order to formulate strategies for improving the quality of learning and entrepreneurship development in this field (Sipangkar et al., 2020). Important aspects that need to be assessed include the availability and condition of laboratory infrastructure and facilities, such as equipment, materials, and learning media (Isma, 2021), as well as the performance of laboratory managers (Seprianto et al., 2022).

The agricultural industry currently requires highly competent workers in tissue culture (Ningsih et al., 2023; Rahmi, 2023), given the importance of this technique for the development of superior varieties and large-scale plant production. Unfortunately, many vocational agriculture schools in Indonesia lack adequate tissue culture laboratory facilities (Nasir & Mayasri, 2023), resulting in graduates who are less prepared to meet the demands of the workplace and find it difficult to contribute to the development of the agricultural sector (Nazri et al., 2022). Common problems encountered include a shortage of equipment, materials, and human resources (Bhojwani & Dantu, 2013), as well as the non-fulfillment of national SOP, which leads to suboptimal

quality in learning practices and entrepreneurship development (Makmur & Mulyaningrum, 2018). Research on the readiness of tissue culture laboratories in vocational schools is needed to determine the current conditions and identify the factors that influence them (Mulyaningrum et al., 2014). The research results are expected to provide information for schools, education authorities, and stakeholders to formulate strategies for improving the quality of tissue culture laboratories in vocational schools (Samanhudi et al., 2020), so that vocational agriculture graduates not only possess technical competence but also have a resilient character and are ready to contribute to the advancement of Indonesia's agricultural sector (Azahra & Ernayunita, 2023).

Tissue culture laboratories must possess to support practical learning and entrepreneurship development for students (Andriani & Heriansyah, 2021; Nasir & Mayasri, 2023). However, many vocational agriculture schools in Indonesia still lack adequate tissue culture laboratories or have not utilized them optimally (Rizki et al., 2021; Hasrawati et al., 2022). An integrative evaluation of various aspects of tissue culture laboratories in vocational agriculture schools needs to be conducted to identify gaps between the existing conditions and established standards, as well as to develop targeted improvement strategies (Sucahyo et al., 2023).

While previous studies have extensively focused on laboratory-scale tissue culture media optimization, systemic evaluations regarding infrastructure readiness and management systems in vocational high schools which integrate both learning and entrepreneurship aspects remain significantly limited (Cholifah et al., 2025; Rahayu et al., 2019). The aspects that need to be assessed include facilities (building design and layout), infrastructure (equipment, availability and placement of tools and facilities), administrative systems, the implementation of occupational health and safety standards, the dynamics of laboratory activities, and support for learning process facilitators and entrepreneurship development (Prasetyo, 2021; Zahara, 2017).

Measuring the readiness of tissue culture laboratories in vocational agriculture schools can be done through various indicators, such as the completeness of infrastructure and facilities, the competence of the laboratory managers, the effectiveness of practical activities, and the contribution to innovation development (Isma et al., 2021; Sipangkar et al., 2020). The building's design and layout (infrastructure) must support sterile and aseptic activities. Physical facilities (equipment) such as laminar

flow hoods, autoclaves, and incubators must be available and strategically placed (Beyl, 2018). Good administrative management, including the inventory of tools and materials, documentation, and equipment maintenance, is very important to consider (Pamies et al., 2022). Occupational health and safety aspects must also be a top priority to protect laboratory personnel (Anis, 2021).

Laboratory dynamics, which include interactions between personnel and waste management, need attention. Waste management in the laboratory must be carried out comprehensively, starting from sorting, collecting, storing, transporting, to disposal or treatment (Sholehah et al., 2022). In addition to research, tissue culture laboratories can also be utilized as a means of learning and product development to support entrepreneurial activities. The novelty of this study lies in the development of a specialized observation instrument designed to assess tissue culture laboratory readiness in vocational schools, addressing not only technical facilities but also laboratory dynamics in supporting school production units (entrepreneurship) according to industry standards.

The results from the tissue culture laboratory readiness observation in this study can serve as a basis for schools, education authorities, and other stakeholders to formulate strategies for improving the quality of tissue culture laboratories in vocational agriculture schools. Through continuous measurement, it is expected that tissue culture laboratories in vocational agriculture schools can become effective learning centers, support the development of entrepreneurial innovation, and produce graduates who are ready to contribute to the advancement of the agricultural industry sector in Indonesia.

Method

This research is a descriptive quantitative study that analyzes seven main aspects: 1). infrastructure aspect (building design and layout), 2). facilities aspect (physical facilities, needs, and placement of laboratory equipment), 3). laboratory administration aspect, 4). occupational health and safety aspect, 5) laboratory dynamics aspect, 6). learning process support aspect, and 7). development for entrepreneurship aspect. The observation instrument was initially designed for each aspect into several assessment indicators, and its validity was then assessed through constructive validation by two expert lecturers in the field of Tissue Culture. This activity aimed to obtain a valid instrument for measuring these seven aspects. The indicators for the seven aspects can be seen in Table 1.

Table 1. Infrastructure Aspect Indicator Grid (Building Design and Layout).

Element	Assessment Indicator	Total Items
Infrastructure (building design and layout)	General Laboratory Layout Requirements	9
	Biology Laboratory Design	7
	Lab Entrance, Exit, and Corridor	6
	Ventilation and Safety Equipment	4
Total		26

Table 2. Grid of Indicators of Facility Aspects (Physical Facilities, Needs and Placement of Laboratory Equipment)

Element	Assessment Indicator	Total items
Facilities (physical facilities)	Laboratory Space Division	6
	Practicum Room	13
	Preparation Room	9
	Storage Room	6
	Incubation Room	5
	Sterilization Room	4
	Washing Room	5
	Laboratory/Teacher Room	10
	Laboratory Maintenance	8
	Infrastructure (Equipment Needs and Placement)	Completeness of Laboratory Equipment
Arrangement and Storage of Equipment		5
Laboratory Equipment Maintenance		3
Arrangement and Storage of Materials in the Laboratory		6
Chemical Material Storage		7
Requirements		
Total		113

Table 3. Indicator Grid for Laboratory Administration Aspects.

Element	Assessment Indicator	Total Items
Laboratory Administration	Administrative Components	8
	Tasks of Laboratory Organizational Structure	5
	Laboratory Room Administration at School	8
Total		21

Table 4. Indicator Grid for Occupational Health and Safety Aspects

Element	Assessment Indicator	Total Items
Occupational Health and Safety	Availability of Personal Protective Equipment (PPE) and Emergency Equipment	7
	Waste Management	3
Total		10

Table 5. Laboratory Dynamics Aspect Indicator Grid.

Element	Assessment Indicator	Total Items
	Laboratory Access Procedures	4
	Frequency of Use	1
	User Involvement	1
	Productivity in Research and Development Activities	2
Total		8

Table 6. Indicator Grid for Supporting Aspects of the Learning Process.

Element	Assessment Indicator	Total Items
Learning Process Support	Alignment with the curriculum and learning objectives	20

Table 7. Indicator Grid of Development Aspects for Entrepreneurship.

Elemen	Indikator Penilaian	Total Items
	Products and Services	3
Utilization for Entrepreneurs	Market and Marketing	4
	Production and Operational Resources	4
hip	Laboratory Finance	4
Total		19

The instrument validation test in this research used Aiken's V method. The selection of Aiken's V as the validation metric is grounded in its efficacy for quantifying expert consensus on content relevance, providing a rigorous statistical basis to transform qualitative judgments into an objective validity index (Aiken, 1985). Specifically, this method serve to calculate the content validity coefficient (Torres-Malca et al., 2022), which indicates how well the items in an instrument represent the construct or concept being measured (Nurjanah et al., 2023). Furthermore, in the context of laboratory research, Aiken's V can measure the validity of the instrument used to assess the 7 aspects of the laboratory, which in this study were based on the total expert judgment. This methodological choice ensures that the assessment items are not only theoretically sound but also practically sensitive to the operational nuances of vocational laboratories, bridging the gap between instructional requirements and industrial standards (Ismarau et al., 2025). Accordingly, the blueprint for the instrument validation is detailed in Table 8.

Table 8. Instrument Assessment by Expert

No.	Assessment Indicator of the Instrument
1.	The questions in the instrument are stated clearly and easy to understand.
2.	The questions in the instrument are relevant to the aspects of tissue culture lab readiness.
3.	The answer choices in the instrument are complete and do not cause ambiguity.
4.	The order of the questions is logical and easy to follow.
5.	The language used in the instrument is easy to understand and not convoluted.
6.	The instrument covers all important aspects in the assessment of tissue culture lab readiness.
7.	The weight or score for each question is clear and proportional.
8.	The instrument can be relied upon to measure the readiness of the tissue culture lab.
9.	The instrument can be easily filled out by respondents.
10.	The instrument can provide objective and accurate assessment results.

The Aiken's V Validity Coefficient is interpreted into the V Index categories in Table 8. The Aiken's V Coefficient formula used by (Nuriyanti et al., 2022) in their research is as follows:

$$V = \frac{\sum S}{n(C-1)} \tag{1}$$

Where:

V = Aiken's V validity coefficient

ΣS = The sum of the average total scores given by the experts for each instrument item.

n = The number of experts providing the assessment

C = The number of rating categories (e.g., if using a Likert scale of 1-4, then C = 4)

Table 9. V Index Category

Index	Category
≤ 0,4	Less Valid
0,4 - 0,8	Valid
> 0,8	Very Valid

(Zavira & Sari, 2023)

The instrument reliability in this research was evaluated using Inter-Rater Reliability (IRR) to measure the degree of consensus between the two experts during the validation process (Rau & Shih, 2021). The IRR was assessed using the Percent Agreement method, supported by the Cohen's Kappa coefficient to determine the consistency of scores assigned by the raters (Li et al., 2023). In this regard, Kappa may be appropriate for macrostructure, as it accounts for the systematic agreement across the diverse dimensions of the laboratory readiness assesment (Rau & Shih, 2021). The percent agreement was calculated by dividing the

number of items rated identically by both experts by the total number of assessment items. Theoretically, a Cohen's Kappa coefficient or agreement level of 0.75 is considered to demonstrate good reliability and substantial consistency between raters (Gisev et al., 2013).

The validated observation instrument was directly used for observation in the Tissue Culture Laboratory of the Plant Agribusiness Expertise Program at SMK Negeri 1 Pandak Bantul. The observation results obtained were then analyzed using the readiness value formula. The laboratory readiness value was categorized based on the criteria in Table 9, according to the percentage results entered into the formula used by (Muhammad, 1992) as follows:

$$\% = (n / N) \times 100 \% \tag{2}$$

Where:

n = The value obtained by respondents from all aspects.

N = The total maximum possible value from all aspects.

% = The percentage of laboratory readiness.

Table 10. Laboratory Readiness Criteria

Interval	Readiness Level Criteria
81% - 100%	Very Ready
61% - 80%	Ready
41% - 60%	Moderately Ready
21% - 40%	Less Ready
< 20 %	Not Ready

(Indriastuti et al., 2013)

Result and Discussion

The validation score results from the observation instrument of the seven aspects by two tissue culture experts are shown in Table 11. The validation was conducted to ensure that the instrument used can accurately measure the readiness of the tissue culture laboratory. Thus, this instrument is expected to provide objective and representative data regarding the conditions of the vocational school-level tissue culture laboratory being observed.

Based on Table 11, the Aiken's V validity coefficient values for the seven aspects of the tissue culture laboratory instrument show positive results. The V values obtained range from 0.585 to 0.661. The lowest V value is 0.585, obtained for the laboratory dynamics aspect, while the highest V value is 0.661, obtained for the development for entrepreneurship aspect. The peak validity score in the entrepreneurship aspect reflects a high consensus among experts regarding the instrument's alignment with the strategic shift in vocational education towards 'Teaching Factory' (TEFA) models (Sarifudin & Suhri, 2024). Conversely, the lower

yet valid score for laboratory dynamics suggests that while the items are representative, this aspect involves more complex, qualitative interactions that require precise wording to minimize ambiguity. If these V values are interpreted into the V Index categories, where values between 0.4 and 0.8 are categorized as "Valid," it can be concluded that the instrument used to measure the seven aspects of the tissue culture laboratory has met the validity criteria. This indicates that the items within the seven aspects of the instrument are relevant and representative for measuring the readiness of Tissue Culture Laboratories in Vocational Agriculture Schools.

Table 11. Value of Aiken's V Validity Coefficient on Instrument Seven Aspects of Tissue Culture Laboratory

Observation Aspect	V	Category
Infrastructure Aspect (Building Design and Layout)	0.625	Valid
Facilities Aspect (Physical Facilities, Needs, and Placement of Laboratory Equipment)	0.655	Valid
Laboratory Administration Aspect	0.645	Valid
Occupational Health and Safety Aspect	0.634	Valid
Laboratory Dynamics Aspect	0.585	Valid
Learning Process Support Aspect	0.644	Valid
Development for Entrepreneurship Aspect	0.661	Valid

The validation results also included feedback provided by the validators, which consisted of minor revisions involving adjustments and the addition of details to the wording. These inputs indicate the validators' focus on clarity and completeness of information. In aspect 1, the addition of the detail "direction of the laboratory door opening outwards" aims to ensure the safety of laboratory users in emergencies (Perry & Baum, 2018). In aspect 3, the addition of the detail "The laboratory has a vision, mission, and description of its usage functions" aims to provide a comprehensive understanding of the laboratory's objectives and role for users (Weiskirchen et al., 2023).

Meanwhile, in aspect 5, the addition of the detail "the existence of analysis/equipment rental fees in the laboratory that will be charged to users from outside the institution/school (for research/training)" aims to provide transparency regarding potential costs for external users (Desai et al., 2016). The validators' emphasis on integrating safety protocols and financial transparency indicates that laboratory readiness is no longer viewed solely through technical availability, but through a holistic management lens that meets both

safety standards and professional accountability (Akase & Kpera, 2024).

The confirmed validation of these seven distinct aspects demonstrates that the instrument effectively captures the multidimensional nature of vocational laboratories, bridging the gap between pedagogical needs and industrial-scale operational requirements (Pavlova, 2019). Thus, the results of this study provide evidence that the instrument used has good validity in measuring the seven aspects of the tissue culture laboratory, namely the infrastructure aspect, facilities aspect, administration aspect, occupational health and safety aspect, laboratory dynamics aspect, learning process support aspect, and development for entrepreneurship aspect (Nuriyanti et al., 2022).

The Inter-Rater Reliability (IRR) resulted a Percent Agreement of 77.14%, derived from 108 identical ratings out of 140 assessment items between the two experts. Furthermore, the calculation of Cohen’s Kappa coefficient resulted in a value of 0.77. These results indicate a substantial level of agreement and consistent judgment between the validators (Marcolan et al., 2022). Referring to the reliability benchmarks, a coefficient above 0.75 confirms that the observation instrument possesses high internal consistency and is dependable for assessing the infrastructure and management standards of the tissue culture laboratory (Gisev et al., 2013)”. This finding confirms that the instrument is not only valid in terms of content but also reliable for assessing the multidimensional aspects of laboratory readiness (Li et al., 2023).

The observation results for the seven aspects are presented in Table 12. Based on the observation data in Table 12, a general overview of the tissue culture laboratory's condition can be seen. Overall, the average readiness percentage of the laboratory is 76.72%, categorized as "Ready." Three aspects show a "Very Ready" level with percentages above 80%: Infrastructure (Building Design and Layout) at 84.61%, Facilities (Physical Facilities, Needs, and Placement of Laboratory Equipment) at 85.84%, and Laboratory Administration at 85.71%. Meanwhile, the other four aspects show a "Ready" level with percentages between 60-80%: Occupational Health and Safety at 70%, Learning Process Support at 80%, and Development for Entrepreneurship at 68.42%. The aspect that requires more attention is Laboratory Dynamics, which shows a "Less Ready" level with a percentage of 62.5%. This data indicates that although the tissue culture laboratory is generally in a ready condition, several aspects, particularly Laboratory Dynamics, require improvement and enhancement to optimize laboratory performance.

Table 12. Tissue Culture Laboratory Observation Data

Observation Aspect	Total Score	Max Score	%	Criteria
Infrastructure (Building Design and Layout)	22	26	84,61%	Very Ready
Facilities (Physical Facilities, Needs, and Placement of Laboratory Equipment)	97	113	85,84%	Very Ready
Laboratory Administration	18	21	85,71%	Very Ready
Occupational Health and Safety	7	10	70%	Ready
Laboratory Dynamics	5	8	62,5%	Less Ready
Learning Process Support	16	20	80 %	Ready
Development for Entrepreneurship	13	19	68,42 %	Ready
Average Percentage			76,72%	Ready

Overall, the laboratory shows a “Ready” level of preparedness (76.72%), indicating that the fundamental components required to support learning and entrepreneurship activities are generally available. However, this level of readiness also suggests that the laboratory has not yet achieved optimal performance across all aspects. In particular, the gap between highly rated aspects (infrastructure, facilities, and administration) and lower-rated aspects (laboratory dynamics and entrepreneurship development) indicates that the availability of resources has not been fully supported by effective utilization and management practices. This finding highlights that laboratory readiness is not only determined by physical completeness, but also by how effectively the laboratory is managed and used in practice.

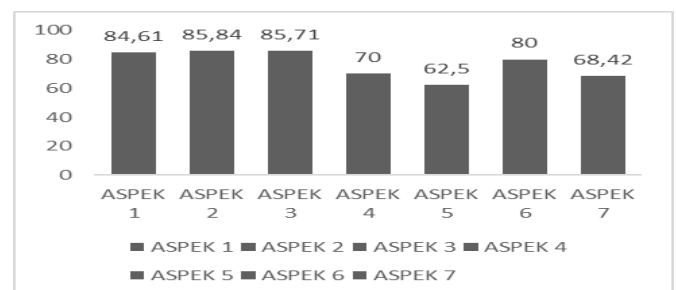


Figure 1. Graph Comparing Laboratory Readiness Across the Seven Aspects.

The analysis of the graph in Figure 1 shows that the tissue culture laboratory generally has a strong foundation, especially in terms of infrastructure,

facilities, and administration. This indicates sufficient investment to support research and development activities. Additionally, the laboratory has paid attention to important aspects such as occupational health and safety, learning process support, and the potential for commercializing research results. However, the laboratory dynamics aspect, which includes practical activities, equipment usage, and laboratory maintenance, requires more attention. The low percentage in this aspect indicates obstacles such as a lack of training, time constraints, or a lack of understanding regarding the importance of maintaining laboratory conditions. Therefore, further efforts are needed to improve the laboratory dynamics aspect so that the overall performance of the laboratory can be further optimized.

Tissue Culture Laboratory Infrastructure (Laboratory Building Design and Layout).

Out of a total of 26 indicators in the infrastructure aspect, the laboratory scored 22, indicating that most requirements have been met. Of the 10 indicators related to the general laboratory layout, 9 were met, except for the availability of a storage room with a minimum size of 20 m². The following section details the building construction and safety equipment aspects. Aspects such as the roof, roof support structure, walls, and the availability of sinks generally meet the standards. However, some shortcomings need attention. The corridor width is less than 2.4 m (only 1.7 m), which does not meet the minimum standard (Basri et al., 2020). Although natural light and air ventilation are met, exceeding 10% (Syakbania & Wahyuningsih, 2017), the availability of eyewash stations and emergency showers as indispensable safety equipment is inadequate, with only regular washing taps available (Sa'Roni, 2020). Overall, while the laboratory meets many design and layout criteria, improvements to the corridor width and the provision of standard-compliant safety equipment are critical to enhance the quality and safety of the laboratory.

These findings indicate that although the laboratory infrastructure is generally adequate, several critical aspects related to safety and spatial standards still require improvement. The insufficient corridor width and lack of emergency safety equipment may reduce the effectiveness of evacuation procedures and increase potential risks during laboratory activities (Basri et al., 2020; Ahmed et al., 2024). This suggests that infrastructure readiness should not only focus on availability, but also on compliance with safety standards and functional efficiency (Roy et al., 2025). Similar studies have emphasized that proper laboratory design plays a crucial role in ensuring both user safety

and the effectiveness of practical learning activities (Syakbania & Wahyuningsih, 2017).

Tissue Culture Laboratory Facilities (Physical Facilities, Equipment Needs, and Placement).

Based on observations conducted on 66 indicators of the facilities aspect within the physical facilities element of the tissue culture laboratory at SMK 1 Pandak, the laboratory generally has several strengths and weaknesses that need attention for quality and safety improvements. The laboratory is equipped with an incubation room (orchid) that meets the standard temperature of 25-28°C (Alič et al., 2017), humidity of 60-70%, and lighting. A sterilization room with an autoclave and disinfectant (Oratmangun et al., 2017), as well as a washing room with adequate facilities such as sinks, detergent, and drying racks (Sari et al., 2024), are also available. The greenhouse shown in Figure 2 for acclimatizing tissue culture results is also available with a strategic location and easy access. Routine daily and monthly maintenance is carried out, and the maintenance process is well-documented. The management of chemical materials also demonstrates good practices in replacing expired materials and grouping them based on their properties. This aims to maintain the quality of the stored chemicals (Suslistya & Mahadewi, 2023). Expired or contaminated chemicals can produce inaccurate data and waste time and resources. The availability of PPE in the laboratory assistant's room and occupational safety equipment such as fire extinguishers and first aid kits are also positive points.

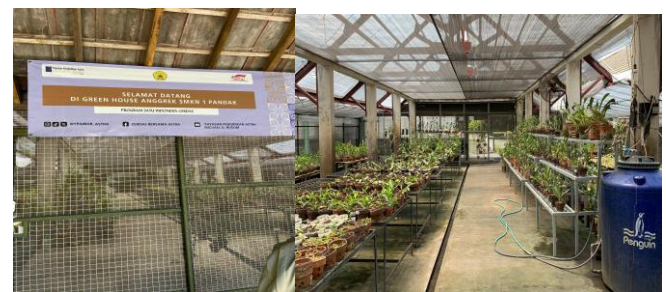


Figure 2. Front and Interior View of the Tissue Culture Plant Acclimatization Greenhouse at SMK Negeri 1 Pandak

The main problem with the physical facilities lies in the size and capacity of the practicum room in Figure 3, which is inadequate as it can only accommodate a maximum of 20 students, while the number of students in one practicum session is 35. The room is too small to accommodate the ideal number of students, potentially disrupting learning effectiveness and student comfort (Sumual et al., 2023). An ideal tissue culture laboratory has four main rooms: a washing room, a media

preparation room, a sterile room, and a culture room (Bhojwani & Dantu, 2013). However, in reality, there is a merging of room functions: the practicum room is combined with the equipment and material storage room in Figure 3, the incubation room is combined with the sterilization room (Laminar Air Flow) in Figure 4, and the administration and laboratory assistant's room is combined with the preparation room in Figure 5. Combining laboratory rooms can create workflow problems and potentially pose safety risks and contamination (Dhanakoses et al., 2023). The most pressing issue is the improper separation of hazardous substance storage from laboratory equipment. This poses a significant risk of corrosion to the equipment and danger to laboratory users (Álvarez-Chávez et al., 2019).

These limitations indicate that, despite the high availability of equipment, the effectiveness of laboratory use may still be constrained by spatial and organizational issues. The merging of laboratory functions and inadequate room capacity can disrupt workflow, increase the risk of contamination, and reduce the overall efficiency of practical activities (Dhanakoses et al., 2023; Alpha et al., 2025). This finding reinforces the idea that the quality of laboratory facilities is not only determined by the completeness of equipment, but also by proper layout planning and functional organization (Pamies et al., 2022).. Therefore, improving spatial arrangement and room allocation is essential to maximize the utilization of existing facilities (Raharjo, 2017).



Figure 3. Tissue Culture Laboratory Practicum Room at SMK Negeri 1 Pandak Combined with Equipment Storage Area (Storage Cabinets).



Figure 4. Tissue Culture Laboratory Incubation Room at SMK Negeri 1 Pandak Combined with the Sterilization Room (Laminar Air Flow).



Figure 5. Tissue Culture Laboratory Administration and Laboratory Assistant's Room at SMK Negeri 1 Pandak Combined with the Preparation Room.

The laboratory also requires clear written procedures for waste disposal in the sterilization room and washing procedures in the washing room. The absence of these procedures could potentially lead to contamination and hygiene issues. The chemical material recording system also needs to be improved to align with the time of receipt (Ismail & Prihatini, 2023). Weekly maintenance needs to be scheduled regularly, separate from practical activities (Raharjo, 2017). Information regarding fire extinguisher facilities, details of the preparation room door, and the size of the storage room needs to be completed for a more comprehensive evaluation (Nadillah et al., 2022).

Based on the observation results of the facilities aspect, element of needs, and placement of equipment, which includes 47 indicators, several important conclusions can be drawn. In general, the tissue culture laboratory at SMK 1 Pandak demonstrates several strengths in terms of equipment completeness and chemical material management. Almost all the equipment needed for tissue culture activities, ranging from sterilization equipment such as autoclaves and laminar air flow hoods (Wulandari et al., 2022), incubation equipment such as incubators and shakers (Kustiani, 2020), to supporting equipment such as analytical balances, measuring cylinders, and other glassware, is available. Chemical material management also shows good practices in terms of complete labeling (name, concentration, expiration date) (Laila, 2021), availability of PPE (Mukherjee et al., 2023), and separation of storage areas from heat sources (Gusmanto, 2023). Regular checks of labels and chemical identification are also carried out. This demonstrates a commitment to good and safe laboratory practices.

This tissue culture laboratory facility still has some significant shortcomings that require serious attention. First, although in general chemical storage is separated, there are exceptions that are very dangerous, namely the storage of alcohol, formalin, and spritus in close

proximity. These three materials are flammable, so close storage has the potential to cause a fire (Nadillah et al., 2022). Second, hazardous chemicals are not placed in locked cabinets or rooms, so access by unauthorized parties is possible. This is a serious violation of laboratory safety standards (Laila, 2021). These two issues need to be addressed immediately as they concern life safety and the potential for great damage. In addition, although the availability of equipment is very good, observations have not recorded the number of each piece of equipment and how they are placed in the laboratory. This information is important to ensure work efficiency and user comfort. By addressing these shortcomings, the tissue culture laboratory of SMK 1 Pandak can maximize its existing potential and become a truly representative facility that supports quality and safe learning activities.

Tissue Culture Laboratory Administration System.

The evaluated vocational school-level tissue culture laboratory has also shown good efforts in administrative management. Most indicators related to the existence of important documents, activity planning, coordination, and room management have been fulfilled (Suslistya & Mahadewi, 2023). This indicates a reasonably good systematic approach in carrying out activities in the laboratory. However, there are some findings that need attention. One of them is related to the suboptimal availability of safety equipment, as fire extinguishers and first aid kits are stored in the school warehouse (Sari et al., 2023). In addition, the laboratory's organizational structure also needs to be clarified and well-documented (Amalatus et al., 2021). To improve the quality of laboratory management in the future, it is recommended to conduct periodic evaluations (Pratiwi & Mulyono, 2023), complete documentation, and socialize the applicable procedures and regulations to all laboratory users (Novitasari et al., 2024). Thus, the tissue culture laboratory can become an effective and safe learning facility for students.

These findings suggest that although administrative components are generally available, their implementation has not yet been fully optimized. Incomplete documentation and unclear organizational structures may lead to inefficiencies in laboratory management and coordination among users (Amalatus et al., 2021). Previous studies have shown that well-structured laboratory administration is essential for ensuring consistent procedures, improving accountability, and supporting effective laboratory operations (Sari et al., 2023). Therefore, strengthening administrative systems is necessary to enhance overall laboratory performance (Pratiwi & Mulyono, 2023).

Occupational Health and Safety (OHS) in Tissue Culture.

The observation results of the occupational health and safety aspect in the vocational school-level tissue culture laboratory indicate the presence of some good practices, but also several areas that need improvement. Although most indicators regarding the availability of PPE and emergency equipment have been met, such as the presence of a first aid kit, there are still shortcomings in terms of training for laboratory assistants and responsible teachers in dealing with potential hazards (Bai et al., 2022). In addition, waste management also needs to be further improved with specific handling for hazardous waste (Alifatunnisa et al., 2024). This is very important considering the potential hazards posed by equipment such as autoclaves, which can cause burn threats due to the release of high-pressure hot steam during the sterilization process. The chemicals used to clean the surfaces of tissue culture equipment, such as alcohol, sodium hypochlorite, and hydrogen peroxide, are corrosive and can cause irritation to the skin, eyes, and respiratory tract (Yemiş & Harmancı, 2020). Therefore, more serious efforts are needed to raise awareness and knowledge among all relevant parties about the importance of implementing OHS principles in the laboratory (Abidin & Ramadhan, 2019) to create a safe and comfortable learning environment for all practical activities.

These results indicate that the implementation of occupational health and safety (OHS) in the laboratory still requires significant improvement. The lack of adequate training and incomplete waste management practices may increase the risk of accidents and exposure to hazardous substances (Alifatunnisa et al., 2024). This highlights that OHS readiness is not only determined by the availability of equipment, but also by users' awareness and competence in applying safety procedures (Yemiş & Harmancı, 2020). Strengthening training programs and enforcing safety protocols are therefore essential to create a safer and more sustainable laboratory environment (Tang et al., 2024).

Tissue Culture Laboratory Dynamics.

The observation results indicate that the tissue culture laboratory at the school has shown reasonably good dynamics. Several positive indicators have been achieved, such as the presence of laboratory usage guidelines, recorded student attendance, and student compliance with work procedures (Halek & Naimnule, 2022). In addition, laboratory usage is also quite good, with an average of two activities per month during learning about tissue culture material. Tissue culture involves aseptic techniques that require fine motor skills. Frequent practice will enhance students' expertise in

performing inoculation, subculture, and other techniques. This indicates that the laboratory has been actively utilized for learning activities.

The tissue culture laboratory has also been involved in various activities demonstrating broader dynamics (Gailea, 2023). The presence of laboratory users indicates collaboration with external parties such as agronomy industry partners (Araoye & Egoigwe, 2024). The school's tissue culture laboratory has collaborated with the ASTRA Education Foundation and the Yogyakarta City Agriculture and Food Agency on research projects where students show efforts to integrate the laboratory with community needs.

The dynamics of this tissue culture laboratory still have several aspects that need to be improved. One of them is related to the cost of analysis or tool rental. Although currently the fee is not charged, there needs to be a clear procedure regarding the use of tools and materials, especially if there will be more intensive and large-scale research activities (Piccinno et al., 2016; Lowe et al., 2013). Overall, the results of this observation show that the tissue culture laboratory at the school has good potential to become an active learning and research center. With continuous improvement and development, it is expected that this laboratory can make a greater contribution to the development of the education sector, science and technology in the field of tissue culture.

The relatively low score in the laboratory dynamics aspect indicates that the laboratory has not been utilized optimally despite having adequate facilities. This condition may be influenced by limited frequency of use, lack of structured scheduling, and insufficient technical training for users (Gailea, 2023). As a result, the laboratory's potential to support skill development and innovation is not fully realized (Lowe et al., 2013). This finding is consistent with previous research highlighting that laboratory effectiveness is strongly influenced by the intensity and quality of its utilization, rather than merely the availability of infrastructure (Nuevo, 2024). Therefore, improving laboratory activity management, increasing the frequency of practical sessions, and enhancing user competence are necessary to optimize laboratory performance (Navlekar et al., 2025).

Learning Process Support.

Based on the observation results, it is evident that students are actively involved in various stages of tissue culture practicums. Furthermore, the relevant teacher has also created a tissue culture module, as shown in Figure 6, which can guide the learning process and practicums in the tissue culture laboratory of SMK Negeri 1 Pandak. This indicates that the practicums have

been well-designed to encourage active student participation (Nggolaon et al., 2024). Additionally, the presence of ongoing evaluation and improvement of the learning process demonstrates efforts to enhance learning effectiveness. However, it should be noted that the success of practicums is not only determined by student involvement but also by other factors such as the quality of teaching materials, the availability of equipment, and teacher competence (Anggereni et al., 2021). To further improve the quality of learning, efforts need to be made to ensure that all students can participate optimally in the practicums (Lutfhianti et al., 2024). Thus, the success of practicums depends not only on student engagement but also on the synergy between good practicum design, adequate resource support, and teacher competence in managing the learning process.

These findings indicate that the learning process in the laboratory has been well supported in terms of planning and student involvement (Alemneh et al., 2025). However, the effectiveness of learning is also influenced by other factors such as the adequacy of facilities, class size, and teacher competence in managing practical activities (Amaliah et al., 2026). If these factors are not balanced, the quality of learning outcomes may not be optimal (Ikram & Kenayathulla, 2023). Additionally, this could result in low technical skills, insufficient feedback, and ineffective time management during practical activities (Osaiyuwu, 2025). Therefore, a more integrated approach is needed to ensure that all supporting components contribute effectively to the learning process.

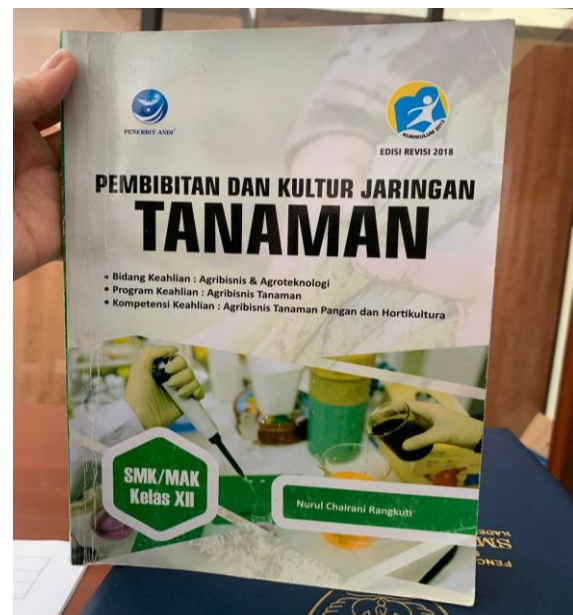


Figure 6. Tissue Culture Learning Module Used in Instruction by the Teacher of the Plant Seed Agribusiness Department in the Tissue Culture Laboratory at SMK Negeri 1 Pandak

Development for Entrepreneurship.

Based on the observation results in this vocational school-level tissue culture laboratory, significant progress has been made in developing the entrepreneurship aspect. The laboratory has successfully produced various tissue culture plant products (Semiarti, 2022), as shown in Figure 7, such as *Dendrobium* and *Cattleya* orchids, and Berlin/Cavendish bananas, and holds ISO certification that guarantees product quality. If a vocational school tissue culture lab collaborates with industry or research institutions, ISO certification can be a requirement to ensure the quality of the results produced (Fayaz et al., 2020). Collaboration with various parties such as Astra and the Yogyakarta City Agriculture and Food Security Agency also demonstrates the laboratory's commitment to developing networks and expanding markets (Camilleri et al., 2023). For example, collaboration with the Agriculture Agency has produced superior Berlin/Cavendish banana seedlings that met the evaluation targets.



Figure 7. *Dendrobium capra*, *dendrobium nobile*, *Cattleya* genus, and *Phalaenopsis* genus. These plants are the result of tissue culture from the SMK Negeri 1 Pandak laboratory, displayed in the Greenhouse for sale at exhibition events.

However, there are still several aspects that need improvement. For example, the competence of teaching staff and laboratory technicians still needs further development (Lewis, 2023), especially in the field of tissue culture. In addition, the budget allocation, which is still focused on orchid plant commodities, needs to be evaluated to encourage product diversification. For example, the laboratory can develop derivative products from orchid plants, such as plant extracts for cosmetics

or herbal medicines. By promoting the diversification of tissue culture plant products, the laboratory can increase product added value and expand its market share (Tiwari et al., 2023). This has shown that the laboratory has great potential to become a center for innovation and the development of high-quality and competitive plant products.

These results indicate that the laboratory has strong potential to support entrepreneurship development, particularly through product innovation and external collaboration (Walsh, 2024). However, limitations in human resource competence and product diversification may hinder the sustainability and scalability of these activities (Acquier et al., 2019). This suggests that entrepreneurship development in vocational laboratories requires not only product output, but also strategic planning, capacity building, and market-oriented innovation. Strengthening these aspects will enhance the laboratory's role as a productive and economically valuable learning center (Lv et al., 2022).

Conclusion

Based on the Aiken's V validity coefficient analysis in this study, the instrument that has been developed and used to measure the seven aspects of the tissue culture laboratory in Vocational Agriculture Schools has proven to be valid, with V values ranging from 0.585 to 0.661. This validation indicates that the instrument items are relevant and representative, and have been refined through minor wording revisions based on validator feedback. Thus, this instrument is reliable for measuring the readiness of tissue culture laboratories.

Based on the readiness percentage across seven aspects, the tissue culture laboratory at SMK Negeri 1 Pandak demonstrates significant potential to become a center for learning, research, and agricultural product development. While currently equipped with adequate facilities for various practicum activities, improvements in teaching staff competence, waste management, and product diversification are essential to transform the facility into a center of excellence.

The scientific contribution of this study lies in the development of a descriptive assessment framework that aligns infrastructure standards with entrepreneurship-based management. Practically, these findings serve as a strategic roadmap for vocational schools to optimize laboratory functions, directly supporting the production of qualified graduates and innovative products. Furthermore, future research should conduct longitudinal evaluations to determine how such laboratory preparedness impacts student

employability and technical mastery within the biotechnology industry.

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Conflicts of Interest

No conflicts of interest.

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