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Vee Diagram-Based Analysis and Reconstruction of a Cheese-Making Practicum Worksheet for Conventional Biotechnology Learning

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Abstract

The biology practicum can connect conceptual knowledge with empirical experience. However, many practicum worksheets remain procedure-oriented and provide limited opportunities for meaningful knowledge construction. This study aimed to analyze and reconstruct one cheese-making practicum worksheet for conventional biotechnology learning using the Vee Diagram. A descriptive evaluative design employing the ANCOR approach Analysis, Try, and Reconstruction was used. The unit of analysis was one worksheet provided by a senior high school biology teacher and selected purposively based on its relevance to conventional biotechnology learning and its suitability for Vee Diagram analysis. The worksheet was evaluated using five Novak–Gowin Vee Diagram components: focus question, objects/events, theory/principles/concepts, records/transformations, and knowledge claims. The initial worksheet obtained a total score of 5 out of 18, equivalent to 27.8% of the maximum possible score. Component attainment was 0.0% for the focus question, 33.3% for objects/events, 50.0% for theory/principles/concepts, and 25.0% each for records/transformations and knowledge claims. The findings indicated that the worksheet emphasized procedural completion and provided limited connections between observable phenomena, empirical data, and relevant biotechnology concepts. The reconstruction incorporated an investigable focus question, lactic acid bacterial fermentation and coagulation concepts, comparative coagulant treatments, systematic data-recording and transformation activities, and evidence-based analysis prompts. The reconstructed worksheet represents an analytically informed, inquiry-oriented laboratory activity design. Further expert review, classroom implementation, and evaluation are required to determine its instructional quality and effects on student learning.

Keywords: ancor; cheese-making practicum; conventional biotechnology; practicum worksheet; vee diagram

INTRODUCTION

Practicum activities are a central component of biology learning because they enable students to connect theoretical concepts with empirical evidence through observation, object manipulation, and direct scientific investigation. When appropriately designed, laboratory activities can make biological concepts more tangible while fostering science process skills, critical thinking, and scientific reasoning (Jeon et al., 2021; Sajidan et al., 2022). These experiences also help students relate conceptual and empirical domains, thereby promoting meaningful learning beyond memorizing scientific concepts (Millar et al., 2002; Novak & Gowin, 1984). Moreover, well-structured practicum activities engage students in interpreting data, formulating evidence-based conclusions, and constructing knowledge from authentic laboratory experiences (Borrul & Valls, 2021; Zahrani et al., 2025). Achieving these purposes requires laboratory designs and student worksheets that extend beyond procedural guidance and deliberately facilitate knowledge construction.

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However, previous studies have reported that laboratory work in schools is still frequently organized around concept verification and prescribed technical procedures. Under these conditions, students primarily follow predetermined steps, with limited opportunities to interpret data, exercise scientific reasoning, or relate their observations to the biological concepts under investigation (Abrahams & Millar, 2008; Supriatno, 2013). Consequently, such activities may resemble cookbook laboratories, where students simply follow prescribed procedures with limited opportunities for meaningful scientific inquiry. Analyses of biology practicum worksheets have similarly identified the absence of clear focus questions, limited opportunities for data transformation, and insufficient prompts for constructing knowledge claims from empirical evidence (Amalia et al., 2025; Tamba & Supriatno, 2024). These limitations indicate the need for a systematic framework to examine and improve how practicum worksheets connect conceptual foundations, observable phenomena, data processing, and evidence-based conclusions.

To address these limitations, the Vee Diagram developed by Novak and Gowin provides an epistemological framework for examining how practicum worksheets connect conceptual knowledge with methodological processes. Its conceptual domain comprises the theories, principles, and concepts underlying an investigation, whereas its methodological domain includes the focus question, objects or events, records, data transformations, and knowledge claims. Explicit connections among these components can guide students beyond procedural completion toward interpreting observations and constructing explanations based on empirical evidence (Novak & Gowin, 1984; Soleh et al., 2025). Previous analyses of biology practicum worksheets have shown that incomplete alignment between the conceptual and methodological domains may restrict the educational value of laboratory activities (Pangsuma et al., 2024; Sari et al., 2025). Therefore, the Vee Diagram offers a relevant analytical basis for systematically identifying worksheet weaknesses and informing their reconstruction.

Previous studies have applied the Vee Diagram to evaluate and redesign laboratory activities across various biology topics. Their findings suggest that explicit alignment among focus questions, underlying concepts, observable events, data records and transformations, and knowledge claims can make the scientific reasoning embedded in laboratory tasks more visible and systematic (Fadilah et al., 2024; Huzaifah et al., 2017; Ling et al., 2019). Beyond its role as a learning aid, the Vee Diagram can therefore serve as an analytical lens for identifying inconsistencies between the conceptual purposes of a practicum and the observations, data-processing activities, and conclusions required from students. This function makes it particularly relevant for reconstructing practicum worksheets whose procedures are not yet adequately connected to their scientific foundations.

Conventional biotechnology provides a relevant context for inquiry-oriented laboratory activities because it involves observable biological and biochemical transformations. Cheese making is particularly suitable for this purpose, as curd formation may occur through enzymatic coagulation, direct acidification, or acid production during fermentation by lactic acid bacteria. These processes provide opportunities to examine the relationships among microbial activity, pH reduction, casein coagulation, curd formation, and whey separation (Coelho et al., 2022). Cheese-making practicum activities also generate measurable observations, including changes in pH, coagulation time, curd texture, curd mass, and whey volume, which can be recorded, compared, and interpreted using empirical evidence (Borrul & Valls, 2021; Jeon et al., 2021). However, previous studies have indicated that biotechnology practicum worksheets are often dominated by procedural instructions and provide limited guidance for connecting observable changes with their underlying scientific concepts (Muzakki et al., 2021). Moreover, direct acid coagulation is not always clearly distinguished from microorganism-mediated fermentation, even though this distinction is fundamental to understanding conventional biotechnology. Consequently, cheese making may be presented merely as a product-oriented procedure rather than as a structured investigation of fermentation and protein coagulation.

Previous studies have applied the Vee Diagram to analyze and reconstruct practicum worksheets across various biology topics and have consistently identified weak alignment between conceptual foundations and methodological activities (Hastika & Supriatno, 2023; Jayah & Supriatno, 2024; Pangsuma et al., 2024; Zahrani et al., 2025). However, the available studies have given limited attention to cheese-making practicum worksheets in conventional biotechnology, particularly worksheets that distinguish direct acid coagulation from lactic acid bacteria-mediated fermentation and connect these processes with observable changes, data transformation, and evidence-based knowledge claims. This study extends previous worksheet reconstruction research by integrating lactic acid bacterial fermentation, pH reduction, casein coagulation, and empirical data processing into the analysis and reconstruction of one selected cheese-making practicum worksheet. Accordingly, the study aimed to analyze the worksheet using the Novak–Gowin Vee Diagram, examine the procedural and conceptual issues identified during the laboratory try-out, and reconstruct the worksheet based on the combined findings. Specifically, this study addressed the following questions: (1) What strengths and weaknesses are evident in the selected worksheet based on the Vee Diagram components? (2) What procedural and conceptual issues emerge during its laboratory try-out? (3) How can the worksheet be reconstructed based on the results of the analysis and try-out?

RESEARCH METHOD

This study employed a descriptive evaluative design using the ANCOR approach: Analysis, Try, and Reconstruction, adapted from Supriatno (2013). Qualitative analysis was conducted to identify the conceptual, procedural, and epistemic characteristics of the worksheet. At the same time, rubric-based scores and percentages were used descriptively to summarize the representation of each Vee Diagram component. The unit of analysis was one cheese-making practicum worksheet intended for conventional biotechnology learning. The worksheet was provided by a biology teacher from a senior high school. According to the teacher, it had originally been downloaded from an online source and used as a reference for practicum activities; however, information regarding the original webpage and authorship was unavailable. The worksheet was selected purposively because it addressed conventional biotechnology, contained a complete cheese-making procedure, was feasible for laboratory implementation, and was suitable for analysis using the Novak–Gowin Vee Diagram. The ANCOR procedure was applied to analyze the worksheet, examine its conceptual and procedural weaknesses through a laboratory try-out, and reconstruct it based on the combined findings. Data were generated through document analysis, rubric-based scoring, laboratory try-out, field notes, and photographic documentation of the practicum activity.

During the analysis stage, the selected worksheet was examined using five components of the Novak–Gowin Vee Diagram: focus question, objects/events, theory/principles/concepts, records/transformations, and knowledge claims. The analysis also addressed the clarity of the practicum objectives, the completeness of tools and materials, the logical sequence and clarity of the procedures, and the alignment between the intended concepts, observable phenomena, and data to be collected. The first author scored each component using an analytic rubric adapted from Novak and Gowin (1984). Each score was assigned based on evidence identified in the worksheet, including its questions, instructions, observation activities, data-recording provisions, and conclusion prompts.

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The scoring results and their supporting evidence were subsequently reviewed by the supervising lecturer. Any differences in interpretation were discussed by referring to the rubric descriptors and worksheet content until agreement was reached.

The try stage was conducted by the first author at the Plant Physiology Laboratory, Universitas Pendidikan Indonesia, over two days, without involving student participants. This stage aimed to examine the clarity and executability of the initial worksheet procedures, identify ambiguous or impractical instructions, document the objects/events that emerged, and determine the types of empirical data generated by the activity. The practicum used commercial vinegar containing acetic acid as the coagulant, with observations focusing on coagulation time, changes in milk and curd characteristics, curd formation, and the appearance of the resulting whey. Procedural difficulties and observable changes were documented through field notes and photographs as the basis for worksheet reconstruction. The try stage was not intended to assess student learning outcomes, worksheet readability, classroom practicality, or instructional effectiveness.

The combined findings informed the reconstruction stage of the worksheet analysis and laboratory try-out. The reconstruction focused on improving the internal alignment among the five Vee Diagram components. Revisions included formulating an investigable focus question, clarifying the objects/events to be observed, strengthening the conceptual relationships among lactic acid bacterial fermentation, pH reduction, and casein coagulation, refining the procedural sequence, adding systematic data-recording and transformation activities, and developing analysis questions that guide the formulation of evidence-based knowledge claims. The reconstructed worksheet was not subjected to expert validation, readability testing, practicality testing, or classroom implementation within the scope of this study. Therefore, it is presented as an analytically informed reconstruction rather than as a validated or effectiveness-tested instructional product.

The primary research instrument was an analytic rubric adapted from the Novak–Gowin Vee Diagram framework. The rubric assessed five components: focus question, objects/events, theory/principles/concepts, records/transformations, and knowledge claims. Each component was evaluated using operational score descriptors that reflected the extent to which it was represented and aligned with the practicum activity. The first author assigned the initial scores based on documentary evidence in the worksheet, while the supervising lecturer subsequently reviewed the scoring decisions and supporting evidence. Differences in interpretation were discussed by referring to the rubric descriptors and worksheet content until agreement was reached. The rubric and its operational scoring criteria are presented in Table 1.

Table 1. Analytic Rubric for Evaluating the Practicum Worksheet Based on the Vee Diagram

Vee Diagram component	Score	Operational descriptor
Focus Question	0	No focus question is provided.
	1	A question is provided, but it is unclear, non-investigable, or unrelated to the observed objects/events.
	2	The question is clear and related to the practicum activity, but its connection with the relevant concepts or objects/events is incomplete.
	3	The question is clear, investigable, and explicitly connects the relevant concepts with the objects/events examined during the practicum.
Objects/Events	0	No observable object or event is identified.
	1	Objects/events are mentioned, but the intended observations are unclear or unrelated to the focus question.
	2	Relevant objects/events can be identified, but the observation guidance is incomplete or limited to the final product.

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	3	Objects/events and observable changes are clearly specified and aligned with the focus question and intended concepts.
Theory/Principles/Concepts	0	No relevant theory, principle, or concept is presented.
	1	Concepts are mentioned but are largely incomplete, inaccurate, or unrelated to the practicum activity.
	2	Some relevant concepts are presented, but the relationships among them and the practicum activity remain weak or incomplete.
	3	Relevant concepts and principles are generally accurate and connected to the practicum activity, although some conceptual relationships are not explicitly explained.
	4	Theories, principles, and concepts are accurate, coherent, and explicitly connected with the focus question, objects/events, and practicum procedures.
Records/Transformations	0	No provision is made for recording or transforming observational data.
	1	Simple observations are recorded, but the data-recording format and observation criteria are unclear.
	2	Systematic recording of raw data is provided, but no meaningful data transformation is required.
	3	Data-recording and transformation activities are provided, but their contribution to comparison or interpretation remains limited.
	4	The worksheet provides systematic data recording and appropriate transformations that support comparison, interpretation, and answering the focus question.
Knowledge Claims	0	No question or instruction guides the formulation of a conclusion or knowledge claim.
	1	The expected conclusion is merely descriptive and is not based on the data obtained.
	2	The conclusion is partially related to the observational data but has a limited connection with the relevant scientific concepts.
	3	The knowledge claim is supported by observational data and linked to relevant concepts, although the integration remains incomplete.
	4	The knowledge claim integrates transformed data with relevant scientific concepts and directly addresses the focus question.

The score obtained for each Vee Diagram component was converted into a percentage using the following formula:

$$P = \frac{F}{N} \times 100\%$$

(Source: Riduwan, 2015)

Where P represents the component attainment percentage, $F$is the score obtained, and $N$is the maximum possible score. The percentages were used descriptively to indicate the extent to which each Vee Diagram component was represented in the initial worksheet. They were not interpreted as evidence of the worksheet's validity, feasibility, or instructional effectiveness. The overall percentage was calculated by dividing the total score obtained across all components by the total maximum score.

RESULT AND DISCUSSION

1. Analysis Stage

The initial cheese-making practicum worksheet was analyzed using the five components of the Novak–Gowin Vee Diagram: focus question, objects/events, theory/principles/concepts, records/transformations, and knowledge claims. The analysis examined the extent to which these components were represented and aligned within the practicum design, particularly the relationship between the intended conceptual foundations and the methodological activities provided in the worksheet. The component scores were used descriptively to identify the worksheet's conceptual,

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procedural, and epistemic limitations and to determine the aspects requiring reconstruction. The results are presented in Table 2.

Table 2. Results of the Vee Diagram-Based Analysis of the Initial Cheese-Making Practicum Worksheet

Vee Diagram Component	Obtained Score	Maximum Score	Percentage (%)
Focus Question	0	3	0.0
Objects/Events	1	3	33.3
Theory/Principles/Concepts	2	4	50.0
Records/Transformations	1	4	25.0
Knowledge Claims	1	4	25.0
Total	**5**	**18**	**27.8**

As shown in Table 2, the initial worksheet obtained a total score of 5 out of 18, corresponding to 27.8% of the maximum possible score. The focus question component received no score because the worksheet did not provide a central investigable question to guide the practicum. The objects/events component was only partially represented, as the observation instructions primarily emphasized the final cheese product rather than changes occurring during the coagulation process. The theory/principles/concepts component obtained the highest percentage, although the conceptual relationships among fermentation, pH change, and milk-protein coagulation were not explicitly developed. Low scores for records/transformations and knowledge claims indicated that the worksheet provided limited guidance for systematically recording observations, transforming data, and formulating conclusions based on empirical evidence. Collectively, these findings show that the worksheet was predominantly procedure-oriented and that the alignment between its conceptual and methodological components required substantial reconstruction.

Focus Question

The focus question component received a score of 0 out of 3 (0%) because the initial worksheet did not provide a central investigable question. The activity began directly with procedural instructions and therefore did not establish a specific problem that could guide observations, data collection, and interpretation. In the Vee Diagram framework, a focus question directs the interaction between the conceptual and methodological domains of an investigation Novak & Gowin (1984). Its absence made the purpose of the practicum largely product-oriented, with emphasis placed on producing cheese rather than examining the biological and biochemical processes involved. This finding is consistent with previous reports that laboratory worksheets lacking explicit investigative questions tend to maintain a procedural rather than inquiry-oriented structure (Silaban et al., 2024).

Objects/Events

The objects/events component received a score of 1 out of 3 (33.3%) because milk coagulation could be identified as the principal phenomenon. Still, the worksheet provided limited guidance regarding the changes that should be observed. The instructions emphasized the final cheese product and did not systematically direct attention to intermediate events, such as the onset of coagulation, curd formation, changes in texture, or whey separation. Consequently, the observable sequence of the process was not fully represented as a source of empirical evidence. Within the Vee Diagram framework, clearly defined objects/events are essential because they provide the empirical basis from which records, transformations, and knowledge claims are developed Novak & Gowin (1984).

Theory/Principles/Concepts

The theory/principles/concepts component received a score of 2 out of 4 (50.0%). Although the worksheet referred generally to conventional biotechnology and cheese making, it did not adequately

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explain the scientific relationships underlying the activity. In particular, direct acid coagulation using vinegar was not clearly distinguished from microorganism-mediated fermentation, and the roles of pH reduction, casein destabilization, curd formation, and whey separation were not explicitly connected. This conceptual limitation may cause the activity to be interpreted primarily as a food-production procedure rather than as an investigation of the biological and biochemical principles involved in cheese making. Similar weaknesses have been reported in biotechnology laboratory worksheets whose procedural steps are insufficiently linked to the relevant scientific concepts (Muzakki et al., 2021).

Records/Transformations

The records/transformations component received a score of 1 out of 4 (25.0%) because the worksheet provided only limited opportunities to document the practicum outcome and did not include a structured format for recording process-related observations. No table was provided for documenting variables such as coagulation time, changes in texture, curd characteristics, or whey appearance. The worksheet also did not require the recorded observations to be organized, compared, or transformed into a form that could support interpretation. As a result, the empirical information generated during the activity could not be systematically linked to the relevant scientific concepts. In the Vee Diagram framework, records and transformations are necessary for converting observations into interpretable evidence that can be used to answer the focus question (Novak & Gowin, 1984).

Knowledge Claims

The knowledge claims component received a score of 1 out of 4 (25.0%) because the worksheet did not provide sufficient prompts for formulating conclusions that integrated empirical observations with relevant scientific concepts. The available questions were predominantly descriptive and did not require the use of recorded or transformed data as evidence. Accordingly, the worksheet was more likely to elicit statements about the final product than claims explaining the relationship among acidification, protein coagulation, curd formation, and whey separation. This weak connection between data and conceptual explanation limited the epistemic coherence of the activity. Previous studies have similarly shown that laboratory worksheets require explicit analytical prompts to guide the formulation of evidence-based knowledge claims (Siregar et al., 2024).

2. Try Stage

The first author conducted the try stage using the initial cheese-making practicum worksheet to examine the executability of the procedures, identify the objects/events generated during the activity, and determine the types of empirical data that could be obtained. The practicum used milk and commercial vinegar containing acetic acid as the coagulant, as specified in the initial worksheet. The procedure successfully produced curd and whey; however, the worksheet directed attention primarily to the final cheese product and provided limited guidance for observing the sequence of changes occurring during coagulation. Thus, potentially relevant events, including the onset of curd formation, changes in texture, and whey separation, were not systematically documented.

The try-out also revealed a conceptual limitation in the representation of conventional biotechnology. The procedure relied exclusively on direct acidification using vinegar and did not include fermentation by lactic acid bacteria. Although acidification can induce casein destabilization and curd formation, the direct addition of acetic acid does not represent the utilization of microorganisms that characterizes conventional biotechnology processes. In cheese production involving lactic acid bacteria, microbial fermentation lowers milk pH through lactic acid production and contributes to casein coagulation and the development of curd characteristics (Fox et al., 2017; Neviani et al., 2025).

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(Agustus 2026), Vol. (16), No. (2)

Therefore, the initial worksheet did not clearly distinguish direct acid coagulation from microorganism-mediated fermentation.

The worksheet also lacked a systematic structure for recording and transforming the observations generated during the practicum. It did not provide tables or other formats for documenting variables such as coagulation time, changes in texture, curd characteristics, temperature, or whey appearance. Consequently, the observations could not be systematically organized, compared, or interpreted as empirical evidence. This limitation was consistent with the low score obtained for the records/transformations component and indicated that the activity was structured primarily as a sequence of procedural instructions rather than as an investigation requiring data analysis (Novak & Gowin, 1984).

The try stage also revealed that most procedural steps in the worksheet were not accompanied by conceptual explanations that could guide students in understanding the scientific reasoning behind each procedure. Students followed the practicum steps mechanically without being directed to relate the milk coagulation process to concepts such as protein denaturation, pH changes, or the mechanisms of coagulant activity. Consequently, the laboratory activities had not fully supported meaningful students' knowledge construction. These findings are consistent with the study by Abrahams and Millar (2008), which stated that overly procedural practicum activities reduce students' understanding of the relationship between laboratory activities and the scientific concepts being learned. Therefore, the try-out results became the basis for reconstructing the worksheet using the Vee Diagram approach so that laboratory activities would become more inquiry-oriented and better support students' knowledge construction.

Furthermore, several procedural steps were not accompanied by sufficient conceptual explanations. The worksheet did not explicitly relate acid addition to pH reduction, casein destabilization and aggregation, curd formation, or whey separation. As a result, the scientific rationale underlying the procedure remained implicit. This finding is consistent with the argument of Abrahams & Millar (2008) that practical activities dominated by procedural completion may provide limited support for connecting observable events with the scientific concepts being investigated. The findings from the try stage were therefore used to determine the procedural, observational, and conceptual elements that required revision during worksheet reconstruction.

3. Reconstruction Stage

The worksheet was reconstructed based on the combined findings of the Vee Diagram analysis and the try stage. The reconstruction aimed to strengthen the alignment between the conceptual and methodological components and to produce a more inquiry-oriented laboratory activity design. Key components of the reconstructed cheese-making practicum worksheet are presented in Figure 1.

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(Agustus 2026), Vol. (16), No. (2)

Figure 1. Key Components of the Reconstructed Cheese-Making Practicum Worksheet

The reconstruction was undertaken to strengthen the alignment between the conceptual and methodological components represented in the Vee Diagram. The revisions included reformulating an investigable focus question, expanding the conceptual foundation to explain lactic acid bacterial fermentation, pH reduction, casein coagulation, and curd–whey formation, and refining the procedure to include comparative treatments using rennet, papaya latex, and a no-coagulant control. Structured activities for data recording, data transformation, and evidence-based analysis were also incorporated. These changes shifted the worksheet from a predominantly product-oriented procedure toward an inquiry-oriented laboratory design that explicitly connects observable phenomena, empirical data, and relevant biotechnology concepts. This orientation is consistent with inquiry-based laboratory learning, which emphasizes observation, evidence interpretation, and the construction of scientific explanations (Jeon et al., 2021; Tamba & Supriatno, 2024).

In the reconstructed worksheet, users are prompted to measure pH before and after fermentation and to record curd formation time, whey color, curd texture, whey volume, and curd mass across the three treatment conditions. The worksheet also requires calculating treatment means and transforming quantitative results into bar graphs, providing a more explicit basis for comparing the effects of the coagulants. Finally, the analysis prompts require the formulation of a knowledge claim that answers the focus question, incorporates quantitative evidence, and connects pH, coagulant type, and curd characteristics. Collectively, these features establish a clearer pathway from objects/events to records, data transformations, and evidence-based knowledge claims. The comparison between the initial worksheet and the reconstructed worksheet based on the Vee Diagram components is presented in Table 3.

Table 3. Comparison of the Initial and Reconstructed Worksheet Across Vee Diagram Components

Vee Diagram Component	Initial Worksheet	Reconstructed Worksheet
Focus Question	No explicit investigable question was provided.	An explicit focus question was formulated to compare the effects of rennet, papaya latex, and a no-coagulant control on curd formation in fermented milk.
Objects/Events	Observations were primarily directed toward the final cheese product.	Fermentation and coagulation events were specified through changes in pH, curd formation time, whey characteristics, curd texture, and curd mass.
Theory/Principles/Concepts	Conventional biotechnology was mentioned, but the relationships among fermentation, pH reduction, and milk-protein coagulation were not explicitly developed.	Conceptual relationships among lactic acid bacterial fermentation, acidification, casein coagulation, and the action of rennet and papain were clarified.
Records/Transformations	No structured observation or data-transformation activities were provided.	Structured observation tables, three replicates, calculation of treatment means, and graphical data transformation were added.
Knowledge Claims	The questions mainly elicited descriptive conclusions without requiring empirical evidence.	Analysis prompts required an evidence-based knowledge claim that answered the focus question and integrated quantitative data with relevant concepts.

As shown in Table 3, the reconstruction modified all five Vee Diagram components, with the most substantial changes occurring in the focus question, records/transformations, and knowledge claims. The initial worksheet did not provide an explicit investigable question and primarily emphasized completing cheese-making procedures. In contrast, the reconstructed worksheet includes a focus question that connects coagulant type with measurable outcomes, including curd formation time, curd mass, and whey volume. The conceptual section was also expanded to clarify the relationships among lactic acid bacterial fermentation, pH reduction, casein coagulation, and the action of different coagulants. Furthermore, structured observation tables, repeated treatments, calculation of mean values, and graphical data transformations were incorporated to establish a clearer pathway from observations to interpretable evidence. The analysis prompts subsequently require an evidence-based knowledge claim that integrates quantitative results with the relevant biotechnology concepts. Collectively, these revisions strengthen the internal alignment between the conceptual and methodological components of the worksheet and shift its design from procedural completion toward a more inquiry-oriented laboratory investigation. This reconstruction follows the rationale of the Vee Diagram framework, in which meaningful laboratory tasks require explicit connections among the focus question, conceptual foundations, observable events, data transformations, and knowledge claims (Supriatno, 2013).

CONCLUSION

The initial cheese-making practicum worksheet showed limited alignment between the conceptual and methodological components of the Vee Diagram, obtaining a total score of 5 out of 18 (27.8%). Its main weaknesses included the absence of an explicit focus question, limited data-recording and transformation activities, and insufficient prompts for developing evidence-based knowledge claims. The try stage further showed that the procedure emphasized direct acid coagulation and the final product without adequately representing lactic acid bacterial fermentation or systematically documenting the observed phenomena. Based on these findings, the worksheet was reconstructed by integrating an investigable focus question, concepts of lactic acid bacterial fermentation, pH reduction, and casein coagulation, comparative treatment conditions, structured data-recording and transformation activities, and evidence-based analysis prompts. The study contributes an analytically informed worksheet design that more explicitly connects conceptual foundations, observable events, empirical data, and evidence-based knowledge claims. However, the study was limited to analyzing one worksheet and a researcher-conducted laboratory try-out. Further research should include expert review of the reconstructed worksheet, readability and practicality testing, classroom implementation, and evaluation of its effects on student learning.

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