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Pre-Learning Supervision Evaluation: Integration of 4Cs and 21st-Century Graduate Profile Dimensions

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Abstract. Twenty-first-century education requires the mastery of critical thinking, creativity, communication, and collaboration skills (the 4Cs) and their integration into instructional practices. Research indicates that the implementation of the 4Cs into lesson plans remains suboptimal, both in terms of the equitable distribution of indicators and their alignment with the Pancasila Graduate Profile dimensions. This underscores the need for an in-depth evaluation at the pre-instructional stage to assess lesson plan readiness in supporting 21st-century competencies. This study offers a novel, comprehensive evaluation of chemistry lesson plans on the topic of redox reactions, emphasizing the integration of the 4C skills and eight dimensions of the Pancasila Graduate Profile. A systematically developed supervision matrix instrument was employed, covering document components, learning objectives, instructional strategies, assessment, learning media, and classroom management, providing a holistic overview of lesson plan readiness. The study aimed to: (1) evaluate the pre-instructional stage through analysis of lesson plans on redox reactions with a focus on the integration of the 4Cs and Graduate Profile dimensions, and (2) assess lesson plan readiness to support effective, contextual, and competency-oriented 21st-century learning. This study employed a descriptive qualitative approach, with senior high school (SMA/MA) chemistry lesson plans as the research object. Data were collected through document analysis, indirect observation, and evaluator triangulation. The results indicate that instructional planning was developed comprehensively and aligned with problem-based learning (PBL), the understanding by design (UbD) framework, the 4Cs, and the Pancasila Student Profile. However, improvements are needed

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through the explicit inclusion of learning outcomes and the completion of reflective documents such as teacher journals. Teachers are advised to explicitly incorporate learning outcomes in the learning objective flow to clarify the link between objectives and expected achievements, as well as to incorporate teacher journals as a medium for continuous reflection. In addition, the explicit articulation of 4C skills and Pancasila Student Profile dimensions in lesson plan documents should be reinforced to ensure more directed and effective instructional implementation.

Keywords: pre-learning supervision; RPP evaluation; 4C skills; Graduate Profile dimensions; 21st-century competencies

1. Introduction

Twenty-first-century education requires teachers, principals, and students to not only master subject knowledge but also develop critical thinking and problem-solving, creativity and innovation, collaboration, and communication skills (the 4Cs). Principals must provide appropriate supervision to encourage, direct, and provide sufficient opportunities for teachers to effectively facilitate the development of these 4C skills in their students (Winaryati et al., 2021). The 4C skills constitute a crucial foundation in helping students adapt to rapid global change and to navigate increasingly complex problems. Research has shown that the 4C skills can foster a wider range of knowledge, attitudes, and skills, thereby contributing to students' success in school, the workplace, and in wider life contexts (Kereluik et al., 2013; Wolters, 2011). Moreover, the 4C framework provides opportunities for teachers to enhance their pedagogical, personal, professional, and social capacities, as well as to strengthen their competence in using technology in learning (Sunardi & Doringin, 2020). The results of studies that investigated the 4Cs in the context of teacher education have shown that the 4Cs play a significant role in strengthening teachers' professional, personal, and social capacities (Brandt et al., 2021).

Empirical findings reported by Kain et al. (2024) indicate that the integration of 21st-century skills into instructional documents remains uneven and frequently limited in depth. Teachers often demonstrate conceptual awareness of the 4Cs; however, the systematic translation of these competencies into measurable learning objectives, instructional strategies, and assessment plans is still insufficient. This gap suggests that although the 4C framework has been widely acknowledged, its implementation in formal lesson planning requires more structured guidance and supervision. Although the 4Cs have become relevant, they have not been implemented optimally and consistently by teachers in practice. Teachers are generally familiar with the concept of the 4Cs and acknowledge their importance, but their understanding thereof is still lacking. This limitation is attributed to insufficient professional development and weak institutional support (Care et al., 2018). Similarly, Kain et al. (2024) reported that teachers, students, and policy-makers are constrained by their opinions, attitudes, and perceptions of 21st-century skills. Although they highlight the benefits and potential impact of 4C skills, they have not explored much in terms of practicing their application in the field. This gap highlights the need for more in-depth research on the application of learning methods, assessment instruments, and integration strategies related to the 4Cs.

Through intensive and systematic supervision, principals can collaboratively evaluate teachers' instructional planning and classroom practices. In this process, the principal validates the findings to determine the extent to which 4C skills are effectively integrated and enacted in classroom learning (Winaryati et al., 2021). The quality of supervision will significantly affect the quality of learning. Incomplete, inappropriate, or inaccurate supervision can negatively affect learning quality (Zhou, 2018). These findings are corroborated by Daud et al. (2018), who reported that effective instructional supervision can improve teachers' attitudes and teaching competence. Appropriate efforts need to be made to strengthen the implementation of supervision and supervisory support in learning to foster high-quality teaching practices and to develop teachers with strong pedagogical competence in the classroom.

One of the aspects that greatly determines the success of learning is pre-learning supervision. The literature consistently shows that high-quality supervision contributes substantially to improvements in teacher competence, both in lesson planning and instructional practice (Kraft et al., 2018; Mok & Staub, 2021; Ronfeldt et al., 2023). Supervision that is structured and supported by evidence-based feedback has been shown to enhance instructional clarity, improve pedagogical competence, and shape teacher professionalism and reflective practice (Toh et al., 2022). Nevertheless, persistent challenges—such as time constraints, insufficient training, and limited resources—continue to hinder the effectiveness of supervision (Zepeda, 2017). In fact, in the context of digitalization, supervision must adapt to online platforms, which poses new challenges related to observation and communication (Harris & Jones, 2020).

Despite growing emphasis on 21st-century competencies, obstacles to the effective implementation of the 4C skills persist in schools. Dahlan et al. (2024) emphasized that many teachers experience difficulties in fully integrating the 4Cs into their instructional practices. The readiness of teachers to implement the 4Cs is reflected in planning documents, particularly the lesson plan. Supervision matrix instruments developed in prior research have been shown to support the systematic analysis of lesson plan readiness. However, several studies in the Indonesian context indicate that the integration of the 4Cs into lesson plans remains suboptimal, unevenly distributed, and constrained by teachers' limited understanding (Care et al., 2018; Voogt et al., 2013).

In addition to the 4C skills, lesson plans should holistically reflect the dimensions of the Graduate Profile, including literacy, character development, and the ability to interact globally. International research underscores the importance of professional training for teachers in designing effective 4C-oriented learning (Darling-Hammond et al., 2017). Complementary findings indicate that when lesson plans and learning projects are designed contextually, students demonstrate significant improvements in creativity, communication, and collaboration (Hidayah et al., 2024). Ganal et al. (2019) further argued that teachers require professional training in 21st-century pedagogical competencies, including content knowledge, the effective use of information and communication technologies (ICTs), strategies for fostering critical and creative thinking, and research-informed principles of teaching and learning. In addition,

teachers benefit from self-development training in stress management, interpersonal and communication skills, as well as work–life balance (Ganal et al., 2019). Care et al. (2018) emphasized that teachers' understanding of the 4Cs can be inferred from the quality of the learning documents they produce. The better the teacher's conceptual understanding, the stronger the integration of the 4Cs into their learning and evaluation plans. This phenomenon shows a persistent gap between the ideal conceptualization of 4C integration and its implementation in classroom practice. Consequently, an in-depth evaluation at the pre-learning stage is essential to ensure the readiness of the lesson plans in supporting 21st-century competencies while holistically reflecting the dimensions of the Graduate Profile. Ganal et al. (2019) emphasized the importance of conducting a needs assessment as the basis for designing relevant training programs to enhance teacher performance and student learning outcomes. Building upon supervision-based evaluations, needs assessment plays a crucial role in identifying specific areas requiring instructional improvement.

Liu and Aryadoust (2024) demonstrated that structured feedback mechanisms – particularly the integration of peer and teacher feedback – significantly enhance learners' cognitive, behavioral, and emotional engagement. Their findings suggest that systematic evaluative processes, when followed by targeted feedback strategies, can produce synergistic improvements in learning outcomes. This reinforces the importance of supervision models that not only diagnose instructional gaps but also inform actionable follow-up interventions. Moreover, the combination of peer and teacher feedback produces a synergistic effect in that it enhances public-speaking engagement and performance. The novelty of this research lies in the development and application of a comprehensive pre-learning supervision evaluation approach. This study not only assesses the extent to which the 4C skills are integrated into lesson plans but also systematically examines how the eight dimensions of the Graduate Profile are reflected in instructional documents. Using a supervision matrix that encompasses document preparation, learning objectives, teaching materials, instructional strategies, assessment, learning media, classroom management, and the integration of the 4Cs in relation to the Graduate Profile, this study provides a comprehensive overview of lesson plan readiness for teaching the topic of redox reactions.

Based on this description, the objectives of this study are to:

1. Evaluate the pre-learning stage through analysis of lesson plans on redox reactions, with a focus on the integration of 4C skills and the dimensions of the Graduate Profile.
2. Assess the readiness of lesson plans to support the implementation of effective, contextual, and competency-oriented learning with 21st-century education demands.

2. Methodology

2.1 Type of Research

This study used a descriptive qualitative approach, focusing on the analysis of lesson plan documents on the topic of redox reactions. This approach was chosen to examine the extent to which the lesson plans holistically integrate 21st-century skills (4Cs) and the eight dimensions of the Graduate Profile.

2.2 Research Object and Subject

The research object consisted of lesson plans on redox reactions implemented by teachers at the senior high school/madrasah aliyah (MA) level. The research subjects were the chemistry teachers responsible for developing and implementing these lesson plans.

2.3 Research Instruments

The assessment instrument was developed to evaluate lesson plans prepared by the teachers. Lesson plans serve as a preparatory document that guides instruction before learning activities are implemented. The assessment framework was based on three stages of lesson plan evaluation, namely, antecedent, transaction, and interim product. *Antecedent* refers to the preparation stage prior to lesson planning. *Transaction* involves the evaluation of learning planning related to the instructional process carried out by the teacher in the classroom. *Interim product* pertains to the assessment of learning planning outputs, including learning outcome planning and formative assessment design. The instrument was structured around the four 21st-century skills, namely, critical thinking and problem-solving, creativity and innovation, collaboration, and communication. The pre-supervision stage was conducted to assess the readiness of lesson plans, examining the extent to which teachers had prepared and planned effectively, as well as to evaluate the lesson plans or learning program plans prepared by the teachers.

2.4 Evaluation Tools Used

The evaluation was conducted using the 6 CELL Stages of the Learning Supervision Evaluation Model, developed by Winaryati et al. (2021). This model, referred to as the "Learning Supervision Evaluation Model Based on Four Traits of 21st-Century Skills" (MESp 4Cs) serves as a structured tool for assessing learning supervision. MESp 4Cs allows teachers, in collaboration with their peers, to evaluate lesson plans and instructional practices in order to generate actionable recommendations for improving learning quality. The approach of MESp 4Cs follows Stage 6 of the CELL Learning Supervision Evaluation Model (Figure 1), providing a systematic framework for pre-supervision assessment and reflective practice.

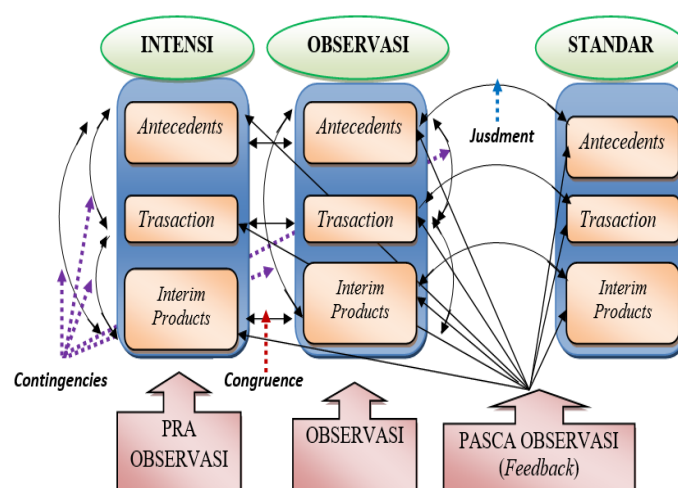


Figure 1: Stage 6 of the CELL Learning Supervision Evaluation Model

The evaluation was conducted using Stage 6 of the CELL (Context–Evaluation–Learning–Linkage) Learning Supervision Evaluation Model developed by Winaryati et al. (2021). This model, known as MESp 4Cs, provides a structured framework for systematically examining lesson planning and instructional readiness. Stage 6 specifically emphasizes reflective evaluation through judgment, congruence, and contingency analysis, allowing supervisors to assess the alignment between instructional intentions, observed planning components, and expected competency standards. The model therefore supports both quantitative scoring and qualitative interpretation to generate actionable recommendations for instructional improvement. The overall assessment procedure is illustrated in Figure 2.

Assessment			Average rating			
Value	Description		3,25-≤ 4	2,51- ≤ 3,25	1,76-≤ 2,5	1-≤ 1,75
1	None					
2	Less					
3	Enough					
4	There is/according to		Category			
		Description	Complete	Accepted with minor revisions	Accepted with many improvements	Rejected

Figure 2: Assessment instructions: Mark √ on the value 0/1/2 in the column provided

The qualitative assessment focused on examining the congruence between the documented lesson plan and its projected instructional implementation. Evaluators analyzed each indicator within the supervision matrix to determine whether the planned instructional components aligned with the stated objectives, strategies, and assessment design. Indicators demonstrating alignment were marked as consistent, whereas those lacking coherence were identified as discrepancies. In addition to categorical judgments, evaluators provided narrative annotations to elaborate on contextual strengths, gaps, or areas requiring further clarification. This qualitative procedure complemented the quantitative scoring by offering interpretive insights into the depth and coherence of 4C integration within the lesson plans.

2.5 Data Collection Techniques

Data were collected using several triangulation techniques. First, document analysis was conducted by examining the lesson plans prepared by teachers. This was done using a learning supervision evaluation instrument prepared by the researchers. This instrument integrates the 4C skills with the dimensions of the Graduate Profile and has undergone prior validation. Second, indirect observation was used to assess the completeness and suitability of the lesson plans with the 4C indicators and the dimensions of the Graduate Profile. Third, to achieve triangulation of assessor sources, the evaluations were performed independently by three chemical education lecturers, each with more than ten years of teaching experience.

2.6 Data Analysis Techniques

Data were analyzed using a qualitative descriptive analysis in three stages. First, data reduction involved selecting relevant information from the lesson plans related to the integration of the 4Cs and dimensions of the Graduate Profile. Second, data presentation was conducted by compiling the findings into a supervision matrix table, which illustrates the achievement of each indicator. Third, interpretation was performed by evaluating the readiness of the lesson plans to support effective, contextual, and competency-oriented 21st-century learning. In addition, quantitative data were obtained by assessing the existing assessment matrix.

3. Discussion and Results

The Indonesian government enacted Regulation of the Minister of Primary and Secondary Education of the Republic of Indonesia Number 10 of 2025 concerning Graduate Competency Standards in Early Childhood, Basic, and Secondary Education (Kementerian Pendidikan Dasar dan Menengah, 2025). In Chapter II, Article 4, paragraph 1, the regulation specifies that graduate competency standards should reflect the eight dimensions of the Graduate Profile to be mastered by students at the end of each educational level. The eight dimensions are faith and piety toward God Almighty, citizenship, critical reasoning, creativity, collaboration, independence, health, and communication. The Ministry of Education has mandated deep learning as the primary instructional approach in schools. The discussion in this article emphasizes strengthening the integration of the 4C skills within instructional planning, informed by insights obtained during a focus group discussion (FGD) conducted as part of the instrument validation process. The FGD involved three chemistry education lecturers with more than ten years of teaching experience and one senior high school chemistry teacher. The discussion aimed to refine the supervision matrix by incorporating explicit indicators related to the eight dimensions of the Graduate Profile, as mandated by recent national policy. The inclusion of these dimensions ensured that the evaluation framework remained aligned with both 21st-century competencies and current regulatory standards. Based on the explanation above, supervisory activities include, first, planning in the form of the preparation of lesson plan documents, which include accompanying documents and tools (pre-learning stage). Second, the implementation of learning encompasses the instructional process, including preliminary activities, core learning, and assessment. Third, post-learning reflection is carried out as an evaluative activity to produce recommendations for improving future learning practices.

This article focuses on special evaluations conducted by supervisors during the pre-learning stage. The evaluation comprised three stages: (1) preparation (antecedent), (2) planning (transaction), and (3) learning outcome planning (interim product). The purpose of this pre-learning supervision was to assess the readiness of lesson plans and instructional planning prepared by high school chemistry teachers. The assessment addressed the following aspects:

1. Preparation of documents, including learning objective flow and lesson plan.
2. Formulation of learning objectives that are specific, operational, and measurable.

3. Preparation of learning materials and strategies appropriate to the teaching context.
4. Integration of 4C skills: critical thinking, creativity, communication, and collaboration.
5. Integration of the Graduate Profile dimensions: faith and piety toward God Almighty, citizenship, critical reasoning, creativity, collaboration, independence, health, and communication.
6. Assessment planning covering cognitive, affective, and psychomotor domains.
7. Availability and use of media and learning facilities.
8. Classroom management and active learning strategies.

The data obtained from the pre-learning supervision evaluation, based on the 4Cs, were used to answer the research objectives.

3.1 Evaluation Results

This article focuses exclusively on pre-observation activities, based on the analysis of lesson plans for the topic of redox reactions in the field of chemistry. The instruments used for this evaluation have been validated and implemented in schools. The evaluation followed the framework developed by Winaryati et al. (2021), specifically Stage 6 of the CELL Learning Supervision Evaluation Model. The assessment was structured around three stages, namely, antecedent, transaction, and interim products.

Antecedents refer to conditions that exist prior to the implementation of a program or activity. Antecedents are the inputs or sources in the system, such as student characteristics, instructional goals, available materials, and other pre-existing conditions that may influence learning outcomes. In the context of learning planning, the antecedent represents the preparatory stage of lesson plan development as understood by teachers. This includes the specification of learning outcomes, learning objectives, sequencing of learning objectives, readiness of teaching modules, integration of 4C skills, and alignment with Graduate Profile dimensions.

Transactions refer to the dynamic instructional processes that occur during the implementation phase of learning. This dimension encompasses both the planned instructional activities and their projected execution in the classroom, including the sequencing of learning tasks, time allocation, teacher-student interactions, assessment procedures, and the continuity of instructional processes across multiple meetings. In this study, the transaction stage represents how teachers translate their instructional intentions into structured learning designs grounded in the 4C framework and aligned with the eight dimensions of the Graduate Profile.

Interim products assess the relationship between antecedents and transactions, and the processes used to produce changes. They describe the relationship between the antecedents and transactions as well as the temporary outcomes, providing information that can guide subsequent improvements. The focus is on monitoring progress and determining the initial impact, influence, or effect of learning planning. The context is examined in line with the process of feedback activities

(Kaufman & Thomas, 1980; Provus, 1969). In the context of learning, the interim product reflects the impact that learning documents have on the implementation of learning plans, including on classroom management and the integration of the 4Cs. The assessment content includes: (1) planning related to learning management outcomes, which encompasses: assessment planning, assessment planning content, as well as the planning of supporting documents; and (2) planning of learning outcomes related to the 4Cs, which encompasses: assessment planning containing the 4Cs and alignment with the eight dimensions of the Graduate Profile.

3.2 Standard, Intent, and Observation

A *standard* is a benchmark/measure that must be met and is expected by stakeholders and the government (Stake, 1977). In this study, the formulation of standards was based on a synthesis of academic supervision instruments, namely: Evaluation of Supervision Programs, the 4C framework, the Guidebook for Peer Evaluation, and the Regulation of the Minister of Primary and Secondary Education Number 10 of 2025 concerning Graduate Competency Standards in Early Childhood, Basic, and Secondary Education. These supervision instruments are flexible, reflective, and oriented toward meaningful learning, while simultaneously strengthening the integration of the Pancasila Student Profile and 4C skills. The regulation specifies eight dimensions of graduate profiles that must be mastered at the end of each level of education, namely: 1) faith and piety toward God Almighty, 2) citizenship, 3) critical reasoning, 4) creativity, 5) collaboration, 6) independence, 7) health, and 8) communication.

Intent refers to a deep depiction of what teachers perceive, intend, and strive to achieve in learning practice (Stake, 1977). Therefore, supervision evaluation does not merely assess what is visible on the surface, but seeks to capture the meaning, purpose, and pedagogical considerations that underlie the teacher's instructional actions. This concept of intent positions supervision as an interpretive and reflective process, in which supervisors aim to understand the alignment between planning, implementation, and learning outcomes. The intention behind supervising learning evaluation is to help teachers reflect on their practice, identify strengths, and find room for constructive improvement.

In the context of the Independent Curriculum, intent is highly relevant because learning emphasizes flexibility, differentiation, and meaningful learning experiences. Supervisors therefore need to explore whether what teachers plan regarding the chosen learning strategies leads to the development of students' potential, fosters learner autonomy, and strengthens 21st-century characteristics and competencies. Learning supervision, in this sense, will measure the achievement of indicators about what teachers intend and what students actually experience in the learning process.

Observation refers to what the observer perceives, experiences, and understands during the supervision process (Stake, 1977). It is not limited to recording observable behavior but also involves the supervisor's professional interpretation of the teacher's learning design. Observation is therefore an interpretive process that requires sensitivity, pedagogical expertise, and reflective judgment from the

observer. What the observer “understands” reflects the extent to which meaningful learning planning—aligned with the goals of the Independent Curriculum, the Pancasila Student Profile, and the strengthening of 4C skills—is designed by teachers. The results of the observation generate systematic evidence regarding the alignment between instructional intentions, documented lesson planning, and expected competency standards. Within the MESp 4Cs framework, observational findings function as empirical indicators for evaluating congruence across antecedent, transaction, and interim product dimensions. These findings not only inform constructive feedback but also support reflective practice and guide targeted professional development interventions aimed at strengthening the integration of 4C competencies and Graduate Profile dimensions.

3.3 Implementation of Evaluation Using the MESp 4Cs Model

The evaluation was implemented through three sequential stages: (1) judgment activities, (2) congruence activities, and (3) contingency (logical relationship) activities. The structure and flow of the MESp 4Cs model are shown in Table 1.

Table 1: Matrix of the MESp 4Cs Evaluation Model

Contingencies	ANTECEDENT			
	Description matrix		Judgment matrix	
	Intent	Observations	Standards	Judgments
	Congruence			
	TRANSACTION			
	Description matrix		Judgment matrix	
	Intent	Observations	Standards	Judgments
	Congruence			
	INTERIM PRODUCT			
	Description matrix		Judgment matrix	
	Intent	Observations	Standards	Judgments
	Congruence			

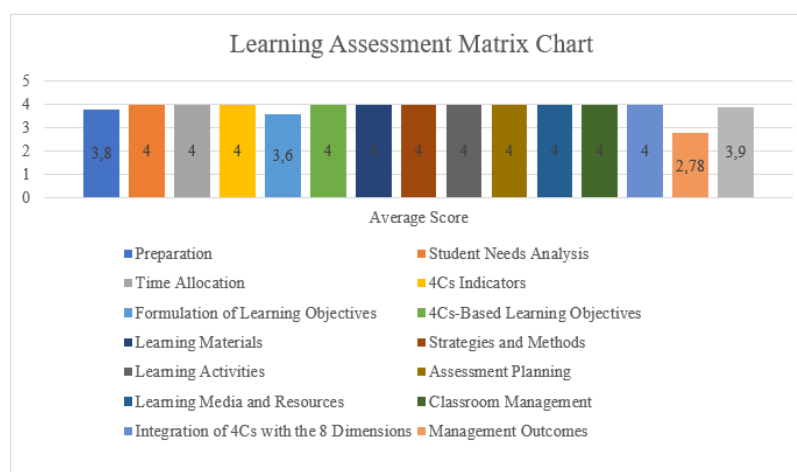


Figure 3: Lesson plan assessment matrix

3.3.1 Data judgment activities between observation results and standards

The assessment was conducted through observation by comparing empirical findings with predetermined standards. The observer evaluated the extent to which the expected criteria (standards) were met in relation to what actually took place (i.e., discrepancies) (Stake, 1977). The results are presented in Figure 3.

3.3.2 Congruence (suitability) of data between observations and intent

Congruence is measured by examining the alignment between intent (what is intended and understood by the teacher) and its suitability with what occurs or is reflected in practice across the antecedent, transaction, and interim product stages. Pre-learning supervision based on the 4Cs places strong emphasis on examining these three dimensions. Accordingly, this section analyzes the suitability between observational data and teachers' intended meaning across antecedent activity, transactions, and interim product.

a) Antecedent

The results of the evaluation at the pre-learning stage, including the learning objective flow and lesson plan, are presented in Table 2.

Table 2: Evaluation of pre-learning supervision at the preparation stage (antecedent)

Aspects evaluated	Evaluation results
Relationship between learning objective flow and learning outcomes	The learning objective flow includes relevant learning objectives and assessment designs; however, the learning outcomes are not explicitly stated. As a result, the alignment between learning goals and competency achievement cannot be fully evaluated.
Relevance of learning objectives	The learning objectives aligned with Phase F require students to be able to classify concepts, not merely explain them.
Learning model	Problem-based learning (PBL) is employed, supporting the development of the 4C skills (critical thinking, creativity, communication, collaboration).
Integration of the Pancasila Student Profile	The learning objective flow integrates dimensions of the Pancasila Student Profile, for example by fostering gratitude for the order of nature through the concept of redox reactions.
Diagnostic assessment	Diagnostic assessments (cognitive and non-cognitive) have been designed according to recommended assessment techniques.
Formulation of learning objectives	The learning objectives are systematically formulated and accompanied by assessments for their achievement, although the learning outcomes are not explicitly stated.
Learning context	Learning objectives are connected to real-life contexts, such as iron corrosion illustrated through the example of a rusty keris (a traditional Southeast Asian dagger).
Learning planning	Learning planning is derived from the learning objective flow, uses a clear instructional syntax, and is oriented toward critical thinking.
Availability of teaching modules	Teaching modules have been prepared for meetings 1–4 and are aligned with all learning objectives.
Adaptation to student characteristics and environment	The learning objective flow has been adapted to students' characteristics, the school environment, and local wisdom, as evidenced by the results of diagnostic assessments.

The lesson plans incorporate environmental and local contextual characteristics, as illustrated in Figure 4.



Dalam suatu proses pemurnian logam, digunakan senyawa kalium dikromat ($K_2Cr_2O_7$). Senyawa ini banyak digunakan dalam proses oksidasi karena ion kromat dalam senyawa tersebut memiliki kemampuan sebagai pengoksidasi yang kuat. Ketika senyawa kalium dikromat dilarutkan dalam air, senyawa tersebut dapat berperan sebagai agen pengoksidasi yang mengoksidasi senyawa lain. Salah satu reaksi dalam pemurnian logam menggunakan kalium dikromat melibatkan perubahan bilangan oksidasi ion kromium (Cr).

Figure 4: Integration of problem-based learning (PBL)

b) Evaluation at the planning stage (transaction)

The planning (transaction) stage focused on learning management planning based on the 4Cs. This stage included: a) analysis of student needs and characteristics; b) time allocation; c) achievement of 4C competency indicators; d) formulation of 4C-aligned learning objectives e) operationalization of 4C competencies; f) learning materials; g) learning strategies and methods; h) learning activities; i) assessment planning; j) selection of learning media and resources; k) classroom management planning; and l) integration of the 4Cs aligned with the eight dimensions of the Graduate Profile. The results of the evaluation at the planning (transaction) stage are presented in Table 3.

Table 3: Transaction stage evaluation summary

Aspects evaluated	Evaluation results
Analysis of students' needs and characteristics	Cognitive diagnostic assessments (e.g., oxidation numbers and reaction equalization) and non-cognitive assessments (auditory, visual, and kinesthetic learning styles) were conducted. Student differentiation into high-, medium-, and low-achievement groups was designed using the Teaching at the Right Level (TaRL) approach.
Time allocation	A total of ten 45-minute sessions were distributed across four meetings. Each meeting focused on different content areas (redox concepts, oxidation numbers, reaction equalization, and real-life applications).
Learning indicators and objectives	Learning objectives were formulated using operational verbs based on the ABCD model. The objectives implicitly reflect the 4C skills (critical thinking, creativity, collaboration, communication), although they are not always explicitly stated. The objectives are aligned with Phase F chemistry learning outcomes (redox reactions).

Learning materials	The materials are organized progressively (simple → complex), covering redox concepts, oxidation numbers, classification, reaction equalization, and applications. The content is contextualized using real-life examples (e.g., corrosion of a keris, batteries, metabolism, environmental and energy issues) and integrates cultural values, character education, and faith-related dimensions.
Learning strategies and methods	PBL is implemented using a clear instructional syntax. Collaborative learning is designed in heterogeneous groups (high, medium, low ability) with structured role distribution (e.g., recorder, presenter, researcher).
Learning activities	Learning activities include discussion, investigation, product creation (e.g., posters or learning media), presentations, and reflection. Contextual real-world phenomena are used to foster critical and creative thinking skills.
Media and learning resources	Learning resources include student worksheets, PowerPoint slides, textbooks, videos, Kahoot, Internet resources, and real environment contexts. These media support auditory, visual, and kinesthetic learning styles.
Assessment planning	Assessment planning follows the understanding by design (UbD) framework (alignment of objectives, assessments, and learning activities). Assessments cover cognitive, non-cognitive, attitude, and skills domains related to the 4Cs. Instruments include analytical rubrics for collaboration, communication, work products, presentations, and group projects.
Class management	Classroom management is designed around heterogeneous grouping based on ability. The learning atmosphere is positive, inclusive, participatory, and engaging, with specific roles assigned to all students.
Integration of the 4Cs and Pancasila Student Profile	The 4C skills are integrated across learning stages, although they are not explicitly stated. The Pancasila Student Profile is reflected through indicators of mutual cooperation, critical thinking, creativity, independence, and global diversity.

The teachers included an explanation of the UbD framework in the lesson plans, as illustrated in Figure 5.

KOMPONEN INTI (<i>Understanding by Design</i> (UbD))
A. TUJUAN PEMBELAJARAN
Tujuan yang ingin dicapai dari pembelajaran pada pertemuan I adalah:
<ol style="list-style-type: none"> 1. Peserta didik (A) dapat mengklasifikasi (B) konsep reaksi oksidasi-reduksi ditinjau dari pengikatan dan pelepasan oksigen, pelepasan dan penerimaan elektron, serta peningkatan dan penurunan bilangan oksidasi (C) dengan pemahaman yang akurat dan lengkap (D). 2. Peserta didik (A) dapat menentukan (B) bilangan oksidasi unsur-unsur dalam senyawa (C) dengan ketepatan yang sesuai dengan aturan bilangan oksidasi (D). 3. Peserta didik (A) dapat mengklasifikasikan (B) suatu reaksi tergolong reaksi redoks atau bukan (C) dengan menggunakan konsep bilangan oksidasi secara tepat (D). 4. Peserta didik (A) dapat membedakan (B) reaksi autoreduksi dan reaksi konproporsionasi (C) dengan pemahaman yang mendalam tentang perbedaan kedua jenis reaksi tersebut (D). 5. Peserta didik (A) dapat menentukan (B) reaksi redoks yang spesifik (C) dengan ketepatan dalam mengidentifikasi zat pereduksi (reduktor), zat pengoksidasi (oksidator), hasil oksidasi, dan hasil reduksi dari suatu reaksi redoks (D). 6. Peserta didik (A) dapat menyetarakan (B) reaksi redoks dengan metode setengah reaksi dan metode perubahan bilangan oksidasi (C) dengan menggunakan kedua metode yang relevan dan menghasilkan keseimbangan yang tepat (D).

Figure 5: Integration of understanding by design (UbD) framework

c) Learning outcome planning (interim product)

The interim product dimension focuses on the projected learning outcomes reflected in assessment design and supporting instructional documentation. This stage examines two primary components: (1) the coherence of assessment design within overall learning management, including assessment strategies, content alignment, and supporting documentation; and (2) the extent to which assessment instruments explicitly operationalize the 4C competencies and align with the eight dimensions of the Graduate Profile. Through this analysis, the interim product stage evaluates whether instructional planning is capable of generating measurable cognitive, affective, and skill-based outcomes. The results of the evaluation are presented in Table 4.

Table 4: Pre-learning supervision evaluation summary (learning outcome planning)

Aspect	Evaluation results
Initial assessment	Diagnostic assessments (cognitive & non-cognitive) are in place, using elicitation questions related to the rust process, batteries, and oxidation numbers.
Assessment type	<ul style="list-style-type: none"> • Formative: aligned with specific learning objective • Summative: real-world case analysis grounded in the local environment and local wisdom (CRT).
Instruments and documents	Assessment grids, analytical rubrics, student worksheets, handouts, modules, PowerPoint slides, and learning videos are available. However, there is no teacher journal or learning diary.
Assessment techniques	Includes independent and group work and presentations. Assessments are designed to be comprehensive, objective, fair, transparent, and sustainable.
4Cs integration	<ul style="list-style-type: none"> • Critical thinking and problem-solving: redox case analysis, real-world problem-solving. • Creativity and innovation: original products, innovative solutions, presentations. • Collaboration: task division, teamwork, conflict resolution, respect for diversity. • Communication: discussions, presentations, visual appearance and content.
Pancasila Student Profile	The assessment instrument integrates all eight dimensions of the Graduate Profile.
Approach	UbD with measurable goals and PBL for creative products and innovative solutions at cognitive levels 4–6.
Assessment outcomes	The plan measures individual and group contributions, content quality, visual design, creativity, innovation, decision-making, adaptation, mutual aid, and communication.

Local wisdom (culturally responsive teaching; CRT) was integrated into the lesson plans prepared by the teachers. An example is illustrated in Figure 6.



Figure 6: Corrosion on keris contextualized with local wisdom

3.3.3 Contingency activities (logical relationships) between antecedents, transactions, and interim products

A logical relationship between goals, strategies, and outcomes is essential in learning planning. Effective planning considers both conditions and behaviors, including what is desired, anticipated, and the potential effects (Stake, 1977). According to Stake (1977), the evaluator continuously observes and reflects on the instructional process from the beginning, during, and at the end. In this study, the logical relationships among the antecedent, transactional, and interim product dimensions were analyzed based on intent and observation, as follows: (1) the relationship between antecedent and transaction; (2) the relationship between transaction and interim product; and (3) the relationships among antecedent, transaction, and interim product.

a) Relationship between antecedent and transaction

Antecedents refer to the initial conditions of instruction, including learning objectives, student characteristics, teacher competence, the curriculum, and available facilities and infrastructure. These conditions determine and limit the forms of transactions that occur in the classroom. The lesson plans prepared by teachers directed the learning goals and resources designed at the antecedent stage. These plans illustrated an influence on learning strategies, teaching methods, media use, and teacher-student interaction during transactions. There was compatibility between the antecedents and the transactions, which indicates that the teachers adapted their instructional practices to the initial conditions.

b) Relationship between transaction and interim product

Transactions refer to the learning implementation process and reflect the realization of what was planned, including instructional strategies, teaching methods, media use, and teacher-student interaction. The quality and consistency of transactions greatly determine the formation of interim products, namely preliminary learning outcomes that are likely to emerge during and immediately after implementation of the learning plan. The lesson plans prepared reflect

readiness in learning design, aligned with learning goals, student characteristics, and available resources. This alignment enabled learners to demonstrate gradual development in aspects of knowledge, skills, and attitudes. The direction of the interim product was reflected in the planning, which provided opportunities for active involvement of students, understanding of initial concepts, development of critical thinking skills, and the generation of formative assessment outcomes during the learning process. There was a mismatch between planning and learning outcomes that had direct implications for the quality of interim products. The more effective the learning strategies, classroom interactions, and the use of media during transactions, the more optimal the achievement of provisional learning outcomes, which serve as indicators of the achievement of learning objectives and provide a basis for further instructional improvement.

c) Relationship among antecedents, transactions, and interim products

These three dimensions form a coherent system. Antecedents provide direction and prerequisites (readiness), transactions constitute the learning planning mechanisms, and interim products serve as initial indicators of the success of learning plans. This relationship was analyzed by comparing intent (what was planned) with observation (what transpired in practice). Interdimensional conformity was observed, indicating successful implementation and providing a basis for evaluative reflection material for continuous improvement. The logical relationship underlying contingency activities emphasizes that the success of learning is strongly determined by the alignment among the initial conditions (antecedents), instructional implementation (transactions), and interim learning outcomes (interim products). Continuous supervision and evaluation allow for more informed decision-making to improve the quality of learning in a systematic and reflective manner.

4. Explanation of the Results of the Evaluation

4.1 Preparation (Antecedent)

The results of the pre-supervision assessment of antecedent aspects related to the learning objective flow and learning planning yielded an average score of 3.94. Almost all indicators achieved a score of 4, except for the indicator “learning objective flow contains objectives relevant to learning outcomes and class phases”. Although the learning objective flow specifies learning objectives along with an assessment design to achieve them, the learning outcomes were not stated explicitly. As a result, the alignment between goals and achievement cannot be fully assessed. This is significant, as previous research shows that a clear alignment between learning objectives and competency achievement is a key factor in the effectiveness of PBL implementation and competency-based learning (Markula & Aksela, 2022).

Overall, the evaluation results indicate that the learning objectives are in accordance with Phase F, where students are required to be able to classify, not just explain. In addition, the chosen learning model, namely PBL, supports the development of 21st-century skills (the 4Cs) (Rehman et al., 2024). International studies have similarly shown that PBL enhances student engagement, provides authentic learning contexts, and facilitates the integration of the 4Cs into science learning (Hmelo-Silver, 2004; Loyens et al., 2012). The learning objective flow also

integrated the dimensions of the Pancasila Student Profile, for example by fostering gratitude for the order of nature through students' understanding of redox reactions associated with local phenomena such as corrosion in a keris. This approach aligns with the findings of Care et al. (2018) that integrating 21st-century skills with locally grounded character education in learning planning can enhance the relevance of learning and increase students' motivation.

In terms of assessment, the teachers designed both cognitive and non-cognitive diagnostic assessments in accordance with recommended assessment techniques. Hmelo-Silver (2004) also emphasized the importance of repeated assessments within the PBL cycle to support the optimal development of students' critical thinking skills. In addition, learning planning was derived sequentially from the learning objective flow using a clear PBL syntax and was supported by teaching modules for several meetings (Sessions 1–4). This approach aligns with recommendations in the literature that systematic and sustainable planning is a key determinant of successful PBL implementation (Rehman et al., 2024). However, a remaining weakness was that the learning outcomes were not explicitly included in the learning objective flow document. This omission has the potential to weaken alignment between learning objectives and student competency achievements. Markula and Aksela (2022) also noted that the lack of clarity in determining learning achievements or *driving questions* is often the main obstacle to the effectiveness of PBL. Therefore, an important improvement would be to explicitly include learning outcomes so that the alignment between goals, achievements, and assessments is strengthened, while also increasing the accountability of learning planning.

4.2 Planning (Transaction)

In the planning stage (transactions), 12 dimensions and 65 indicators were evaluated, with an overall score of 4. This assessment is supported by the results of the qualitative evaluation, as summarized in the 4Cs (pre-supervision-transaction) evaluation report. The results of the evaluation of the planning stage (transactions) in the 4C-based lesson plans indicated excellent readiness, with an average score of 4 across 12 dimensions and 65 indicators assessed. This suggests that the teachers prepared learning plans in a systematic and structured manner, in accordance with the demands of 21st-century competencies. First, the teachers analyzed students' needs and characteristics through cognitive diagnostic assessments (e.g., oxidation numbers and redox reaction equalization) and non-cognitive assessments (auditory, visual, and kinesthetic learning styles). The differentiation of students based on high-, medium-, and low-ability groups was designed using the Teaching at the Right Level (TaRL) approach (see Figure 7). This is consistent with the findings of Suprayogi et al. (2017), who emphasized the importance of differentiation and formative assessment in designing learning activities that are responsive to student profiles.

E. TARGET PESERTA DIDIK (Pembelajaran Berdiferensiasi (DAP) & <i>Teaching at the Right Level (TaRL)</i>)
1. Peserta didik tingkat tinggi: Mampu menerapkan konsep redoks dalam permasalahan yang lebih kompleks dan menganalisis berbagai metode penyetaraan reaksi redoks.
2. Peserta didik tingkat sedang: Mampu menyelesaikan masalah redoks dengan panduan dan menerapkan metode penyetaraan reaksi redoks yang telah dipelajari.
3. Peserta didik tingkat rendah: Mampu memahami konsep dasar redoks dan melakukan penyetaraan reaksi redoks sederhana dengan bantuan.
4. Kelompok heterogen: Setiap kelompok akan dibagi berdasarkan variasi kemampuan agar tercipta interaksi belajar yang kolaboratif.

Figure 7: Differentiated learning (TaRL)

Second, the time allocation was arranged proportionally, with ten 45-minute sessions distributed across four consecutive meetings covering the basic concepts of redox reactions, oxidation numbers, balancing redox reactions, and real-life applications. This progressive meeting structure makes it easy for students to understand material from simple to more complex topics. Third, learning objectives and indicators were formulated using operational verbs based on the ABCD model. Although the 4Cs were not always explicitly stated, the objectives implicitly incorporated elements of critical thinking, creativity, collaboration, and communication. This is in line with the learning outcomes of Phase F. However, the literature emphasizes the importance of explicitly articulating the 4Cs to facilitate systematic evaluation and reflective practice (Rehman et al., 2024).

Fourth, the learning materials were organized sequentially and contextualized through real-world examples, such as corrosion in a keris, batteries, and environmental and energy issues. The integration of cultural and local contexts has been shown to strengthen student engagement and enhance the relevance of learning (Care et al., 2018). Fifth, the learning strategy adopted PBL with a clear syntax, including discussion, investigation, product creation, presentation, and reflection stages. Collaborative activities were implemented through heterogeneous grouping based on diagnostic data, with clearly assigned roles to ensure structured interaction and balanced participation. Equity of contribution was monitored through rubric-based assessment criteria. Rehman et al. (2024) reported that well-structured and collaborative PBL significantly enhances students' mastery of the 4C skills.

Sixth, learning media were prepared in a variety of formats, ranging from student worksheets, textbooks, PowerPoint presentations, videos, and applications such as Kahoot to real-world environments. This multimodal approach is in line with international findings that media diversity supports different learning styles and facilitates the integration of 4C skills (Kokotsaki et al., 2016). Seventh, assessment planning was based on the UbD framework, following a sequence of learning objectives, assessments, and instructional activities. Assessments addressed cognitive, non-cognitive, attitudinal, and skills aspects of the 4Cs, employing tools such as collaboration rubrics, group projects, presentations, and creative products. Sinnema et al. (2020) support the notion of the effectiveness of UbD in aligning learning objectives, assessments, and activities, particularly in the context of authentic and formative assessment.

Eighth, classroom management was designed to be inclusive and participatory, using heterogeneous groupings to provide all students opportunities to contribute. This approach is consistent with differentiated instruction theory, which emphasizes the importance of equitable and responsive learning that accommodates student diversity (Suprayogi et al., 2017). Overall, the lesson plan showed mature planning, with key strengths in the clarity of the planning sequence (objectives → assessments → activities), integration of real-world contexts, use of diverse media, and implementation of 4C-based PBL. However, areas for improvement include explicitly stating the learning outcomes and clearly formulating the 4C skills to facilitate measurement and evaluation.

4.3 Learning Outcome Planning (Interim Product)

In the evaluation of learning outcome planning (interim product), two variables, five dimensions, and twenty-two indicators were assessed, with an overall score of 4. The exception was the dimension of Planning Supporting Documents, with the indicator “Teacher journal/learning diary”, being rated 2. This lower rating is attributed to the absence of a teacher journal or daily learning record in the submitted planning documents. The evaluation included two main components. The first is: planning related to learning management outcomes, including: a) assessment planning, b) assessment content planning, and c) planning supporting documents. The second component is: planning of learning outcomes related to the 4Cs, including: a) assessment planning that incorporates the 4Cs, and b) assessment planning based on the 4Cs. At the pre-learning supervision stage, the planning of learning outcomes was designed comprehensively by emphasizing both cognitive and non-cognitive diagnostic assessments. Low-stakes questions, for example those related to real-world cases such as rust, batteries, and oxidation numbers, were shown to help explore students’ initial understanding while promoting critical thinking from the outset of learning. This aligns with findings that real-world, context-based diagnostic assessments can enhance student engagement in science learning (Brown, 2004).

The assessment instruments were comprehensive and included grids, analytical rubrics, student worksheets, handouts, modules, and supporting media such as PowerPoint presentations and videos. Formative assessments were designed for each intermediate learning objective, while summative assessments focused on environment-based case analyses and the integration of local wisdom. This approach aligns with the principles of UbD, which emphasizes the measurability of learning objectives through planned assessments. The assessment techniques employed include independent assignments, group work, presentations, and work products. The assessment was comprehensive, objective, fair, transparent, and sustainable, with the support of an analytical rubric. This kind of assessment model allows for a more thorough evaluation of students’ competencies, encompassing not only cognitive but also social and collaborative skills (Black & Wiliam, 1998; Wiliam, 2011).

Integration of the 4Cs was evident in the following ways:

- Critical thinking is developed through case analyses of redox reactions and real-world problem-solving.

- Creativity is fostered through the creation of original products and innovative solutions presented.
- Collaboration is strengthened through task-sharing, teamwork, conflict resolution, and appreciation of diversity.
- Communication is cultivated through discussions, presentations, and the visual presentation of content.

This integration not only supports 21st-century competencies but also aligns with the eight dimensions of the Pancasila Student Profile, especially the dimensions of mutual cooperation, critical reasoning, and creativity. International research has further shown that the integration of the 4Cs into assessment can enhance students' preparedness to face global challenges (Trilling & Fadel, 2021). The learning approach combining PBL with the UbD framework facilitates the measurement of learning objectives. PBL, particularly for fourth- to sixth-grade students, encourages the production of creative, product-based solutions. Recent studies confirm that PBL is effective in developing collaborative and innovative skills, especially when connected to contextual, real-world issues (Dolmans et al., 2016). However, one remaining weakness is the absence of a teacher journal or learning diary. Teacher journals function as a means for continuous reflection, which can enhance the quality of planning and the effectiveness of learning strategies (Farrell, 2019). Thus, even though the assessment planning is thorough and relevant to both the 4C competencies and the Graduate Profile dimensions, further improvement is needed through the inclusion of reflective teacher documentation.

5. Conclusions and Recommendations

Overall, the learning plan was well prepared, comprehensive, and aligned with the principles of PBL, the 4C skills, and the integration of the Pancasila Student Profile. First, for the preparatory stage (antecedent), the learning objective flow included learning objectives, assessments, and sequential learning steps; however, the learning outcomes were not explicitly stated, leaving the connection between the goals and achievements somewhat unclear. Nevertheless, the planning remained contextual, having been adjusted to the characteristics of students, the school environment, and local wisdom. Second, for the planning stage (transaction), the teachers conducted a needs analysis through diagnostic assessments, designed differentiation according to students' abilities, and developed learning objectives using operational verbs aligned with learning outcomes Phase F. PBL-based planning supports contextual, collaborative, and structured learning activities. Assessment planning also employed the UbD framework, addressing cognitive, non-cognitive, attitudinal, and 4C skills. However, the 4C skills and dimensions of the Pancasila Student Profile are not explicitly mentioned in the document. Third, regarding the learning outcome planning stage (interim product), learning outcome planning was comprehensive, innovative, and contextual, supported by various assessment instruments (rubrics, grids, student worksheets, handouts, modules, digital media). The 4C skills were fully integrated into the assessments. One remaining weakness is the absence of teacher journals or learning diaries, limiting the documentation of reflective practice and the continuity of planning. In summary, the learning plan

is mature and in line with PBL, UbD, the 4C skills, and the Pancasila Student Profile, but it requires further strengthening through the explicit inclusion of learning outcomes and the completion of reflective documents, such as teacher journals. Teachers are advised to explicitly include learning outcomes in the learning objective flow to clarify the alignment between learning objectives and student achievements, as well as to incorporate teacher journals as a means of continuous reflection. In addition, the explicit mention of the 4C skills and the dimensions of the Pancasila Student Profile in the lesson plan documents needs to be strengthened to ensure that the implementation of learning is more directed.

Conflict of Interest

The authors declare no conflict of interest. The funders had no role in study design; in data collection, analysis, or interpretation; in script writing; or in the decision to publish the results.

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