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Profiling readiness for deep learning: A study of chemistry students' multiple intelligences and learning reflections

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Abstract. The persistent challenge of promoting deep conceptual understanding over rote memorization in chemistry education requires investigating students' readiness for student-centered learning. This study aims to screen student readiness for deep learning in chemistry by analyzing their multiple intelligences (MI) and reflective learning experiences. Employing a qualitative descriptive method, this study analyzed data from an MI questionnaire and reflective writing assignments from 84 Chemistry Education students (2022–2024 cohorts) selected via purposive sampling at Universitas Lambung Mangkurat. Results revealed that spatial intelligence is the most dominant profile, with 23 of 84 students in this category. Analysis of reflective writing identified Project-Based Learning (PjBL) as the most preferred instructional model for creating meaningful learning experiences, with 29 respondents favoring it. Furthermore, student reflections demonstrated a significant transformation from negative assumptions to deeper understanding, highlighting the development of creativity, critical thinking, and teamwork. These findings suggest that leveraging visual and project-based strategies aligned with students' dominant intelligence and learning preferences can effectively foster readiness for a deep learning approach in chemistry education.

Introduction

Rapid global developments have created learning demands that are far more complex than in previous decades. Ideally, 21st-century education should equip students with a comprehensive set of competencies, including character, citizenship, collaboration, communication, creativity, and critical thinking, enabling them to function effectively as problem-solving citizens in their communities (Fullan et al., 2018; Citrawan et al., 2024). These competencies require students not only to master knowledge but also to engage cognitively, emotionally, and socially in meaningful learning.

However, in higher education, particularly in chemistry education, the reality still shows a persistent gap between these ideal expectations and classroom practice. Many learning activities remain dominated by traditional, content-driven, and teacher-centered approaches. This condition results in surface learning, where students rely heavily on memorisation for examinations and struggle to connect concepts to real-world contexts (Fantiani et al., 2023; Siswaningsih et al., 2020). This situation often leads to misconceptions, low motivation, limited problem-solving skills, and underdeveloped critical thinking, underscoring the urgency of transformative learning practices aligned with the demands of the 21st century. Preliminary findings from 84 students indicated that 67.9% demonstrated surface-level reflective writing, while only 32.1% showed readiness for deep learning. The questionnaire results further revealed diverse multiple intelligence profiles, with no single intelligence type exceeding 25%, highlighting a gap between students' learning characteristics and current instructional approaches.

One pedagogical shift that addresses this challenge is deep learning. Deep learning emphasises holistic engagement through mindful, meaningful, and joyful learning experiences that integrate cognitive, emotional, and physical domains (New et al., 2014). Deep learning has a learning framework. The learning frameworks are a systematic guide to creating an educational ecosystem that supports learning. The main focus of this framework is to encourage meaningful, reflective, and contextual learning through pedagogical practices, learning environments, learning partnerships, and the planned application of digital technology. Deep learning encompasses five essential dimensions: metacognition, communication, and collaboration, deep processing, creativity, and empathetic experiences (Zhang, 2020). Through these processes, students are expected to reconstruct knowledge, integrate new experiences into cognitive structures, and demonstrate higher-order thinking (Niu & Liu, 2022; Widana et al., 2023).

To ensure the effective implementation of deep learning, understanding students' characteristics, particularly their multiple intelligences, becomes crucial. Students possess diverse intelligence profiles, including linguistic, logical-mathematical, interpersonal, intrapersonal, spatial, musical, bodily-kinaesthetic, and naturalistic (Ahmad Walela, 2024). These variations influence how students process information, interact with learning materials, and respond to learning tasks. Previous studies emphasize that aligning instructional strategies with students' intelligence profiles enhances comprehension, motivation, and learning quality (Winarti et al., 2019; Zahroh et al., 2024; Sugihartini & Swisnandy, 2025). Thus, identifying intelligence profiles serves as a strategic step to optimise deep learning implementation.

In addition, reflective writing is an important tool for strengthening learning experiences in a deep learning environment. Reflective writing encourages learners to connect new knowledge without previous experiences, evaluate their own thinking, articulate insights, and build personal meaning (Fatmasari et al., 2024; Kainde & Tahya, 2020; Zahroh et al., 2024). Its advantages include enhanced metacognition, deeper conceptual understanding, and increased learning motivation. However, reflective writing also has limitations, such as the risk of superficial reflection and varying student ability to express ideas effectively (Murillo-Llorente et al., 2021). Integrating reflective writing with deep learning is therefore expected to provide a more comprehensive picture of students' cognitive and emotional readiness for transformative learning.

Although various studies have investigated deep learning, multiple intelligences, and reflective writing separately, integrating these three aspects, particularly in Chemistry Education programs, remains limited (Mulyono et al., 2021; Nhat & Le, 2023; Ramadhanti & Ramadhanti, 2024). Previous research rarely examines how multiple intelligence profiles and reflective writing experiences can be jointly used to analyse students' readiness for deep learning. This gap constitutes the novelty of the present study, positioning it as an important contribution to the design of more personalised and effective chemistry learning in higher education. Therefore, this study aims to identify the multiple intelligence profiles of Chemistry Education students and analyse students' readiness to implement deep learning based on intelligence profiles and reflective writing.

Method

This study employed a convergent parallel mixed methods (Creswell & Creswell, 2018) design to examine Chemistry Education students' multiple intelligence profiles and their readiness to engage in deep learning. In this design, quantitative and qualitative data were collected concurrently, analyzed separately, and then integrated at the interpretation stage to provide a comprehensive understanding of the phenomenon. The quantitative strand focused on identifying students' dominant multiple intelligence profiles using a structured questionnaire, while the qualitative strand explored students' readiness for deep learning through reflective writing. Both strands were given equal priority, and their results were compared to identify convergent, complementary, or divergent patterns. The research procedures are illustrated in the following scheme to provide a clear overview of the stages conducted in this study.

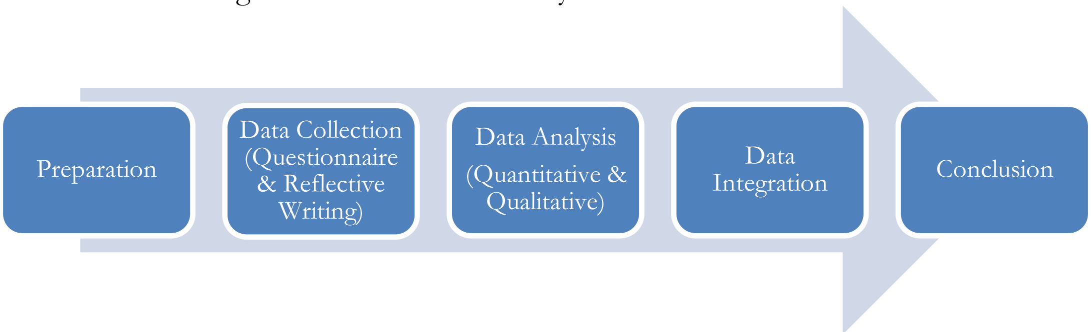

Image 1. Research Diagram

The research was conducted at the Chemistry Education Program, Faculty of Teacher Training and Education, Universitas Lambung Mangkurat, during the even semester of the 2024/2025 academic year. Participants were students from the 2022 – 2024 cohorts, selected through purposive sampling. The inclusion criteria were: (1) having completed at least one semester of study; (2) willingness to complete the questionnaire; and (3) ability to produce reflective writing based on learning experiences. Quantitative data were collected using a Multiple Intelligence questionnaire designed to categorize students into eight types of intelligence. Each intelligence type was represented by several indicators arranged in a structured grid. The questionnaire was administered simultaneously with the reflective writing task. Responses were scored and tabulated to identify students' dominant intelligence profiles. Qualitative data were obtained through reflective writing using the Reflect-Analyse-Action structure. Students were asked to: (1) reflect on their learning experiences; (2) analyze underlying assumptions, challenges, and key concepts; and (3) propose appropriate future learning actions. This reflective model, adapted from Coradim & Barcaro (2011), was used to capture students' readiness for deep learning from an introspective and experiential perspective. Both instruments were administered during the same phase of data collection, in accordance with the convergent parallel mixed methods approach.

The validity of the research instruments was established through content validity based on expert judgment from Chemistry Education experts, ensuring alignment with the research objectives and the construct of multiple intelligences and learning readiness. The reliability of the Multiple Intelligence questionnaire was assessed using Cronbach's alpha, which indicated acceptable internal consistency. The credibility of the reflective writing instrument was ensured through inter-rate agreement, with two independent raters applying the same coding framework to maintain consistency in interpreting students' readiness for deep learning.

Questionnaire data were analyzed using descriptive statistical techniques, including frequencies and percentages, to describe the distribution of students' multiple intelligence profiles. The results provided an overview of dominant and less dominant intelligence types among participants. Reflective writing data were analyzed using an interactive qualitative analysis model consisting of data condensation, data display, and conclusion drawing. Relevant statements were coded and categorized into themes reflecting students' readiness for deep learning, including self-awareness, critical reflection, motivation, and action planning. Visual displays, including tables and diagrams, were used to support interpretation.

Results and Discussion

The presentation of results follows the stages of the convergent parallel mixed-methods design: quantitative findings from the Multiple Intelligence questionnaire, qualitative findings from reflective writing, and the integration of both datasets to explain students' readiness for deep learning.

Analysis of the Multiple Intelligence questionnaire showed that spatial intelligence was the dominant category among 84 Chemistry Education students across the 2022-2024 cohorts. A total of 23 respondents demonstrated strong spatial abilities characterised by sensitivity to visual patterns, colours, and proportional relationships. These findings reinforce Gardner's views that spatial intelligence supports learners in decoding diagrams, models, and chemical structures, which are central to chemistry learning. Previous research by Aspanani et al. (2023) and Fatmasari et al. (2024) similarly notes that spatially strong learners excel in interpreting visual representations used in scientific subjects. In this context, visual-based strategies such as mind maps, diagrams, modelling kits, and flashcards are effective and align with the dominant intelligence profile found in this study.

In addition to spatial intelligence, other forms such as linguistic, logical-mathematical, kinesthetic, musical, interpersonal, intrapersonal, and naturalistic intelligences were observed, although with smaller distributions (Widana & Ratanaya, 2021). These diverse profiles highlight the need for differentiated learning approaches in chemistry classes. This aligns with Syarifah (2019), who argues that learning becomes more effective when instructional design acknowledges students' varied strengths rather than relying solely on linguistic or logical methods. The following are the multiple intelligences results of students from the 2022, 2023, and 2024 cohorts, presented in Image 2.

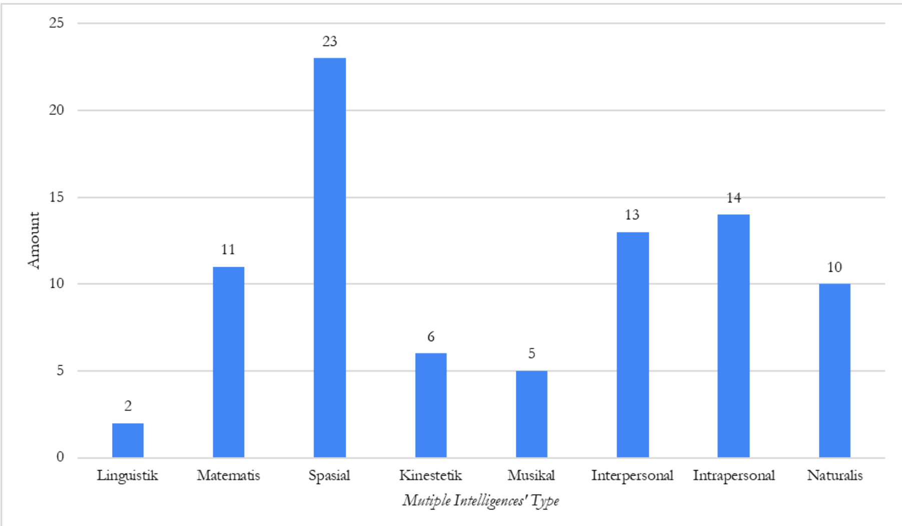

Image 2. Multiple Intelligences' Type of Students from 2022 – 2024

In addition to spatial intelligence, there are seven other types of intelligence, including 1) linguistic intelligence, which refers to the ability to process and use language effectively, both verbally and in writing (Gharibeh-gharibeh, 2025). Linguistic intelligence is the ability to use words well. Students with this intelligence speak fluently, learn languages easily, and can influence others through words. They enjoy activities like writing, literature, theatre, and public speaking. 2) Mathematical-logical intelligence is the ability to work with numbers and reason logically (Widana et al., 2020). People with this intelligence solve problems quickly, think abstractly, and enjoy activities involving math, symbols, and problem-solving. The next type of intelligence is 3) Kinesthetic intelligence is the ability to use the body effectively to express ideas and emotions, often seen in athletes, dancers, actors, and surgeons. Children with this intelligence enjoy physical activities, learn best through hands-on experiences, and are skilled in crafts or imitating movements. 4) Musical intelligence is the ability to create, enjoy, and understand music, with strengths in rhythm, melody, and sound. People with this intelligence may sing, play instruments, compose, or easily recognize musical patterns. 5) Interpersonal intelligence is the ability to understand others' emotions, intentions, and motivations, which helps build strong relationships and communication. Those with this intelligence often excel as communicators, facilitators, or leaders; 6) Intrapersonal intelligence is the ability to understand yourself, manage emotions, and make wise decisions. People with this level of intelligence are self-aware, reflective, and aware of their life goals. It is often stronger in introverts and helps someone become their best self. Together with interpersonal intelligence, it forms part of emotional intelligence. 7) Naturalistic intelligence is the ability to understand and connect with nature. People with this intelligence enjoy being outdoors, can identify plants and animals, and understand their behavior. They care for the environment and often apply this knowledge in activities such as farming, exploring, or studying nature (Karagülmez Sağlam & Doğan, 2025).

A learning strategy is a plan consisting of a series of actions, including the use of methods and various resources in the learning process. In other words, the strategy is still at the planning stage and has not yet entered the implementation stage. This strategy is developed with specific objectives in mind, meaning that every decision made in its development is aimed at achieving those objectives. Therefore, learning steps, the use of facilities, and the selection of learning resources must be focused on achieving the established objectives. Before that, the objectives to be achieved must be clearly formulated and their success measured (Samsinar, 2020).

In the context of learning, the elements of learning strategies are divided into 1) Determining the specifications and qualifications of learning objectives, which are transformations in the behaviour and character of students; 2) Analysing and selecting the most appropriate and efficient learning approaches; 3) Developing and establishing the stages, methods, and techniques of learning to be used; and 4) Formulating standards and minimum thresholds as benchmarks for success, including criteria and indicators of achievement used as references (Syaikhu, 2020). Multiple intelligence learning strategies are an approach to accessing information through the eight types of intelligence possessed by each student (Rismawati & Paais, 2024). In practice, all intelligences work together in a unique way for each person. Since every child has different strengths, learning should be designed to stimulate various intelligences. This requires creative strategies that can develop all potentials in an integrated way.

Reflection in learning is an integral part that is interconnected and mutually reinforcing (Haifa et al., 2023). The purpose of reflection in the learning process is for students to review their learning experiences, recognise what they have understood and what they have not, and evaluate their learning. Reflective writing analysis revealed that Chemistry Education was the field of study most frequently perceived as meaningful, engaging, and awareness-raising, with 53 responses. Data on the fields of study that provide challenging, enjoyable, and meaningful experiences are presented in Image 3.

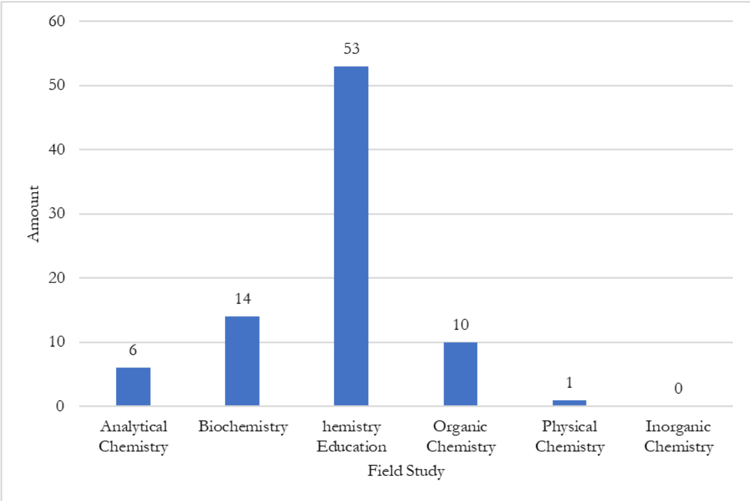

Image 3. Field Study

Students consistently noted that project-based learning (PjBL) created deep and memorable learning experiences because it connected abstract chemical concepts to real-world applications. This aligns closely with the research by Sumarni & Kadarwati (2020), which shows that PjBL increases conceptual mastery and promotes independent investigation in science learning. Students also reported powerful experiences in topics such as wood chemistry, medicinal plant synthesis, acid-base reactions, and electrochemical cells. In teaching courses in this field, lecturers use learning models that make learning enjoyable and meaningful. Data related to learning models are presented in Image 4.

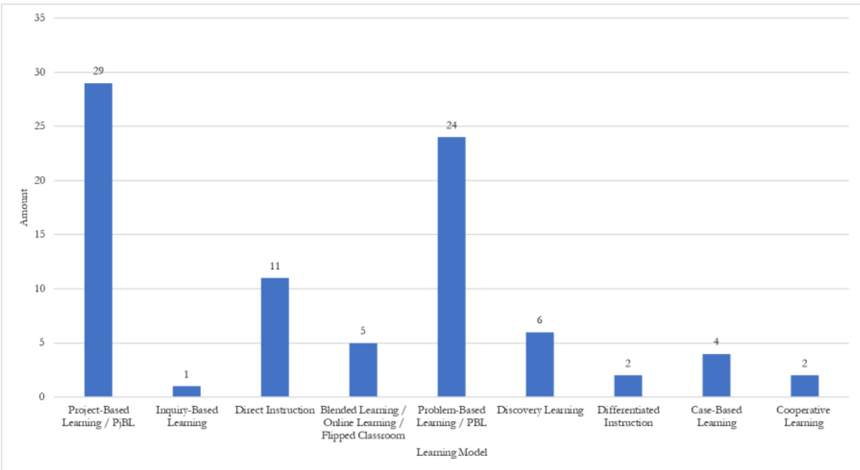

Image 4. Learning Model

Image 4 shows that project-based learning is the most preferred learning model among students, with 29 respondents. Project-Based Learning is a hands-on method that makes learning more active and meaningful for students. The process begins when a teacher poses a big, interesting question about a real-world topic to spark curiosity (Luh Gede Sutaryani et al., 2024; Sobach et al., 2023; Poerwati et al., 2025). Guided by the teacher, students then work together to plan their project, outlining their goals, the steps they will take, and the resources they need (Sumarni & Kadarwati, 2020). After creating their own schedule to learn time management, students begin the hands-on work of researching, experimenting, and creating their project while the teacher supervises and offers help. Once their work is complete, students present their findings to their peers and teacher, showcasing what they learned (Masbukhin et al., 2023; Sudiarta & Widana, 2019). Finally, everyone reflects on the experience, discussing the project's challenges and successes. This entire process, supported by teacher guidance, not only helps students better understand and retain information but also makes learning more engaging and enjoyable.

Apart from their field of study, students naturally have topics that leave a lasting impression. Data related to these topics is presented in Image 5.

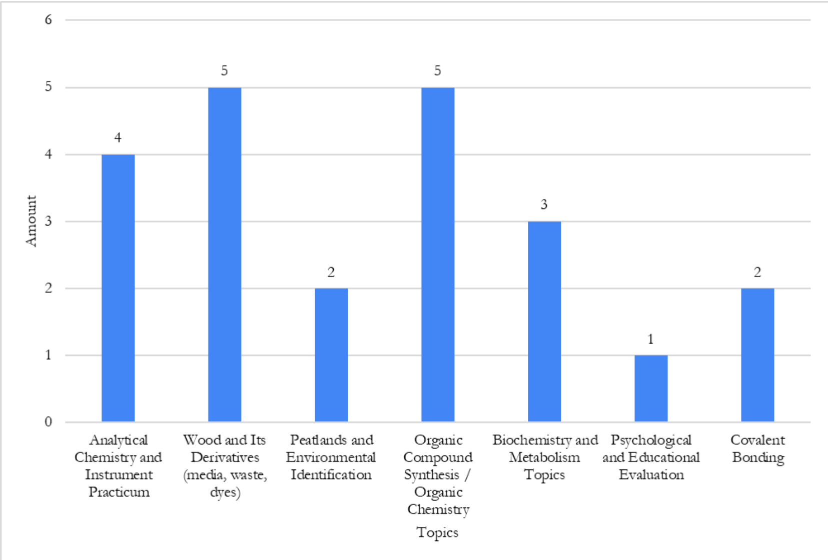

Image 5. Interesting Topics for the Class of 2022

Two topics left the deepest impression on each of the five respondents. The respondents stated their reasons as follows.

"The topics of wood chemistry and pulp were very memorable for me because I learned that wood can be used for many things, such as making fabric, paper, and even natural dyes. I learned that wood waste can also be processed into useful products, such as T-shirt dyes. Hands-on practice helped me understand the chemical concepts better, and I found it exciting because the knowledge can truly be applied in everyday life."

“I am fascinated by the challenge of synthesizing complex organic compounds from medicinal plants. Studying this topic has highlighted the importance of C–C bond formation and demonstrated how lab synthesis enables the controlled, efficient production of beneficial phytochemicals. This has also deepened my core understanding of how molecular structure determines a compound's chemical properties.”

During the learning process, there are memorable topics, presented in Image 6. There are two dominant topic areas: media and learning design.

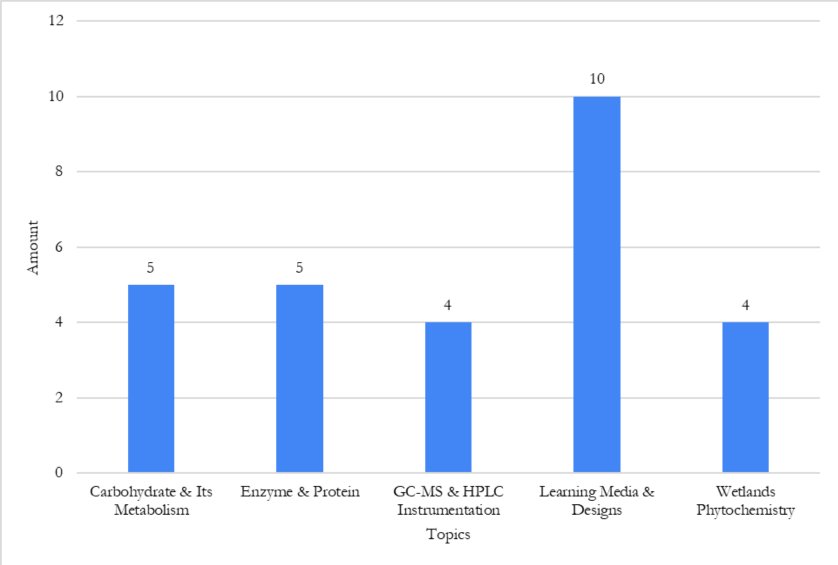

Image 6. Interesting Topics for the Class of 2023

The reasons why students chose these two topics are presented in the following excerpt.
"This material is easy to understand, relevant to everyday life, and delivered through an engaging and contextual active learning method. In addition, this topic is considered applicable, adds new insights, and provides a creative and meaningful learning experience."

During the learning process, there are memorable topics, presented in Image 7. The two most dominant topics are acid-base and electrochemical cells, with 10 respondents each.

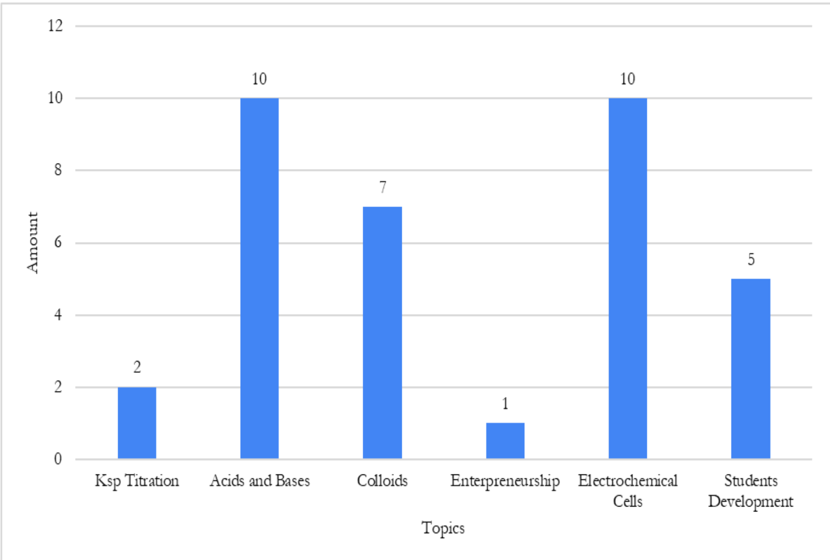

Image 7. Interesting Topics for the Class of 2024

"Electrochemistry is interesting because it deals with chemical reactions involving electron transfer and the conversion of chemical energy into electricity. Its practical applications include batteries, fuel cells, and electroplating. Unique concepts such as redox reactions and Faraday's laws make it both fascinating and important in the development of modern technology."

"The topic that left the deepest impression on me was acids and bases. This topic is very interesting because it is not only studied in theory but also applied in everyday life, such as in cleaning products, food, and even the human body. In addition, when conducting acid-base experiments and observing the colour changes of indicators and the glow of lamps, I found it easier to understand the concepts of pH, electrolyte strength, and ionisation reactions."

From 84 respondents, data were also collected on students' initial assumptions about attending lectures, as well as on exhilarating, meaningful experiences that made students aware of their potential. The data are presented in Table 1.

Table 1. Self-Potency of Students

Category potential/Reflection	Number of Respondents	Example of Self-Realised Potential
Concept Understanding, Materials, and Perseverance	12	Able to understand the concept of molarity and glycolysis reaction; more careful and patient in lab work; able to understand the material if explained to others.
Creativity, Innovation, and the Application of Science	9	Can create colourants from waste wood; able to design and make products from natural materials; design learning media (Articulate); create learning modules.
Independence, Confidence, and Communication	11	Able to complete tasks without assistance; confident in leading groups and answering questions; able to present lab results; able to guide students and explain simple concepts; courageous in public speaking.
Teamwork and Leadership	8	Able to work together in a practicum team; able to divide tasks and help each other when obstacles arise; able to lead the team when compiling case analyses.
Critical Thinking, Analysis, and Problem Solving	10	Able to analyse educational issues; develop learning strategies and evaluation; develop learning modules; and face difficult challenges and analyse case studies.
Environmental Concern and Awareness of the Relevance of Science	7	Realise the potential of surrounding plants as chemical sources; learn to process waste; realise chemistry is all around (food, environment, household products); understand the relevance of carbohydrate and protein topics in daily life.
Interest, Enthusiasm for Learning and Research Interest	9	Finding out about molecular structures on their own, learning more out of curiosity, realising the importance of active compounds and phytochemicals, making bioplastics from sago starch, and taking up the theme of wetlands and phytochemicals.
Self-Learning, Self-Reflection, and Adaptation	10	Gradually learn to prepare a pre-proposal; realise the importance of not procrastinating; realise personal learning style; understand the material in depth and systematically; be able to explain the

Category potential/Reflection	Number of Respondents	Example of Self-Realised Potential
		steps of an experiment; overcome fears and adjust to online lectures.
Technology Utilisation	8	Using apps for learning media, digital learning design, and exploration with digital tools.

To facilitate analysis and drawing general conclusions, the data were then grouped into several main categories based on similarities in meaning and response patterns. The initial assumptions, in the form of student reflections before attending the lecture, are presented in Table 2.

Table 2. Reflection Category

Topics	Reflection Category
Analytical Chemistry and Instrument Practicum	The titration experiment was a great lesson: practical work demands precision and teamwork, not just theory. Our mistakes taught us to be more diligent, proving that learning by doing is more effective than just reading.
Wood and Its Derivatives (media, dyes, and waste)	This project taught us that wood has many uses beyond construction. The hands-on experience of making products like paper or dyes sparked creativity and connected chemistry lessons to real-world applications, proving the value of project-based learning.
Peatlands and Environmental Identification	This field project on peatlands taught us to be independent researchers. Using technology to identify wildlife and presenting their findings built their confidence and environmental awareness. Most importantly, it showed them that hands-on, project-based learning is an effective skill for the future.
Organic Compound Synthesis/ Organic Chemistry	What initially seemed like a difficult, abstract theory became interesting when students saw its real-world applications in making products like soap and candles. Using visual tools like molecular models was crucial for understanding, and the project-based approach successfully taught students how to design experiments, recognize structures, and become more confident and creative.
Biochemistry and Metabolism Topics	Students often find biochemistry difficult, but practical activities, such as protein and metabolism analysis, show that it can be explored with simple tools and applied to food and nutrition. These activities make students more observant, stimulate discussion, and help them understand compound functions in real-life contexts.
Psychological and Educational Evaluation	Through discussions on topics like trauma and learning evaluation, students recognized the importance of mental health, valued diverse opinions, and appreciated open, critical thinking. They found issue-based learning enjoyable, practical, and meaningful.
Covalent Bonding	At first, chemical bonding seemed abstract, but visual models and project-based learning helped students understand molecular structures and bond types. We can

Topics	Reflection Category
	now distinguish single, double, and triple bonds and link them to compound formation.
Carbohydrate and Its Metabolism	At first, I thought carbohydrates were only an unhealthy source of energy. Through discussion and practice, I learned their role in metabolism. Presentations and active participation built my confidence, while everyday examples like fasting made the material easier to grasp.
Enzyme & Protein	Realized the body's complexity and the key role of enzymes in biological processes, became interested in protein and enzyme functions, and became more aware of chemistry's relevance to human life.
GC-MS & HPLC Instrumentation	At first, it seemed complicated, but learning the principles and types of separation in HPLC/GC-MS became clearer through visualisation, analogies, and discussions.
Learning Media & Designs	Creating learning media with new software was enjoyable. Students were motivated by technology-based projects, saw the value of engaging, real-world learning, and became more disciplined through the challenge of design.
Wetlands Phytochemistry	The process of learning phytochemistry through literature and practical work enables students to understand the secondary metabolites contained in plants. It is challenging, but gradually learning becomes enjoyable and meaningful.
Ksp Titration	At first, Ksp seemed simple, but a precipitation titration revealed its true complexity. Watching for faint color changes taught patience, observation, and how indicators work, making Ksp feel real and practical.
Acids and Bases	At first, acids and bases seemed simple, but titrations showed their real complexity. I learned how strong and weak acids behave differently, why indicators matter, and how careful observation is needed. This made acid-base chemistry feel real and practical.
Colloids	At first, I thought colloids would be difficult and unimportant. But after clear explanations, I realized they are very relevant in daily life—like in food, cosmetics, and industry—which made me more interested in learning about them.
Enterpreneurship	At first, I thought entrepreneurship was only about starting a business and making money. I later realized it's about problem-solving, creativity, teamwork, and learning from mistakes. It showed me that entrepreneurship is a mindset, not just a business.
Electrochemical Cells	At first, I thought electrochemical cells were just about electrons moving in a wire. Experiments with voltaic and electrolytic cells showed me how redox reactions at electrodes produce or consume electricity. Seeing metal reactions and voltmeter readings made me appreciate their role in batteries and real-life technology.
Students Development	At first, I thought student development was only about grades. But through teamwork, problem-solving, and class activities, I gained confidence, responsibility, and time

Topics	Reflection Category
	management. I learned that education builds not just knowledge, but also skills and character for the future.

This category reflects the transformation of understanding, skill development, and the formation of positive attitudes during the learning process. Some categories highlight significant changes in cognitive aspects, such as the understanding of previously difficult chemistry concepts that have become easier and more meaningful (Mitina et al., 2025; Raven & Wenner, 2023). Meanwhile, other categories reflect affective and metacognitive aspects, such as increased self-confidence, the ability to collaborate, and awareness of the importance of independent learning and the use of digital learning media.

This categorisation is intended to serve as a foundation for more in-depth learning evaluation and for the design of more adaptive and student-centred teaching strategies. By understanding the general trends emerging from this reflection, educators can respond more effectively to students' learning needs and foster the development of independent, reflective learners who are prepared to tackle real-world challenges (Gupte et al., 2021; States et al., 2023). The strategies and actions students should take are presented below.

The learning process, spanning independent study, collaboration, exploration, hands-on practice, and self-reflection, demonstrates that the development of student attitudes goes beyond academic understanding (Ho et al., 2021). It is deeply shaped by awareness, experience, and active learning strategies. Through various approaches such as engaging with diverse resources, participating in group work, adapting personal learning styles, and applying knowledge in real-life contexts, students have grown into more disciplined, confident, reflective, and adaptive individuals (Leopold & Smith, 2020; Purnadewi & Widana, 2023). They are increasingly able to manage themselves, embrace challenges, and think critically about both academic and practical problems. Overall, this integrated learning experience has fostered the growth of resilient, responsible, and innovative learners well-equipped to thrive in both academic and professional environments (Rost et al., 2025).

The integration of multiple intelligences and reflective writing findings points to an important conclusion: students with spatial intelligence dominance thrive in learning models that are visual, hands-on, project-based, and contextually rich. This confirms the theory that learning becomes deeper and more meaningful when instructional strategies align with the learner's cognitive tendencies. Past studies, Haifa et al (2023); Raven & Wenner (2023), support that reflection cultivates metacognitive awareness, helping students recognise misconceptions and develop the capacity for self-regulated learning.

The novelty of this study lies in the combined use of Multiple Intelligence profiling and structured reflective writing to map students' readiness for deep learning, an integration rarely carried out in Chemistry Education research. While previous studies examined these variables separately, this research demonstrates how intelligence profiles shape learning preferences and how reflective narratives reveal students' evolving understanding, challenges, and personal growth. This dual-method approach offers a more holistic insight into student learning readiness than traditional achievement assessments. Theoretically, this research strengthens the conceptual link between multiple intelligences, reflections, and deep learning readiness. In practice, the findings offer guidance for chemistry educators on designing learning activities that integrate reflective practices and intelligence-based instruction to promote deeper learning.

Despite these contributions, the study has limitations. The sample was restricted to one university and three cohorts, which may limit generalisability. Self-report instruments, such as reflective writing, may also introduce bias. Further research could compare multiple institutions, employ longitudinal tracking, or integrate observational data to strengthen validity.

Conclusion

This study identified that the dominant multiple intelligence profile among Chemistry Education students is spatial intelligence, indicating a strong aptitude for visual and hands-on learning. An analysis of students' learning experiences through reflective writing further revealed their readiness for deep learning, as evidenced by a clear preference for active, engaging instructional models such as Project-Based Learning and a significant shift from apprehension to meaningful understanding when complex topics were taught through practical applications. The reflections confirmed that appropriate pedagogical strategies not only enhance comprehension but also foster essential competencies such as critical thinking, creativity, collaboration, and self-confidence. Therefore, it is recommended that educators design learning strategies that integrate visual elements and project-based activities to align with students' inherent strengths and experiences, thereby optimizing the implementation of deep learning in the chemistry curriculum.

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