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Exploring AI Utilization Patterns Across Curriculum Stages in Chemistry Education

Margarita Claudya Maida[1*], Ifan Rivaldo[1], Nurhamida Anar[2], Putri Permatasari[3]

[1] Department of Chemistry, Universitas Negeri Padang, Indonesia
[2] Chemistry Education Study Program, Universitas Pendidikan Indonesia, Indonesia
[3] Graduate School of Engineering, Gifu University, Japan.
*Corresponding author, e-mail: mclaudyamaida@unp.ac.id

Abstract
Despite growing adoption of AI in higher education, limited studies examine variations across curriculum stages in chemistry education. This study aimed to investigate AI utilization patterns among chemistry students across curriculum stages at Universitas Negeri Padang. A descriptive quantitative survey was conducted involving 162 students from 2021-2025 cohorts. The data were collected using an online questionnaire consisting of closed-ended items covering AI usage frequency, platform preferences, and purposes of use. The data were analyzed using descriptive statistics and cross-tabulation. Results show that AI is widely used, with occasional and frequent use dominating. ChatGPT was the most used platform, followed by Perplexity AI and Google Gemini. Differences in usage patterns were observed across cohorts: early-stage students mainly used AI for conceptual understanding, while advanced-stage students used it more for literature review, academic writing, and research support. These findings highlight stage-based differences in AI utilization and may inform AI literacy development in chemistry education.

Keywords: Artificial Intelligence, Higher Education, Chemistry Education, Curriculum Structure, Generative AI.

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Introduction

Artificial Intelligence (AI) technology has also begun to play an increasingly important role in academic activities (Lorenzo-Lledó & García, 2025; Rodafinos, 2025). The emergence of various generative AI platforms, such as ChatGPT, Google Gemini, and Perplexity AI, has transformed the way students interact with digital knowledge sources. These technologies function not only as information retrieval tools, but are also capable of generating, summarizing, and organizing information contextually according to users' needs (Elhag et al., 2025).

Several studies have reported an increasing use of generative AI among university students, particularly in academic activities such as searching for references, understanding concepts, summarizing learning materials, and completing coursework (Elhag et al., 2025). This indicates that AI has become an integral part of the learning ecosystem in higher education, particularly in response to increasingly complex and dynamic learning environments (Sakhiyya et al., 2025). The responsive, interactive, and adaptive characteristics of AI further enhance its relevance in supporting modern learning processes.

From a technology-based learning perspective, AI can be positioned as a cognitive tool that supports students' independent learning processes (He Li & Elvira S. Balinas, 2025), particularly by facilitating information retrieval, conceptual understanding, and learning efficiency (Kankeviciene et al., 2026). As a cognitive tool, AI can support information processing efficiency by assisting learners in processing complex information, organizing knowledge, and identifying relevant learning resources, thereby enabling greater engagement in higher-order thinking and problem-solving activities (Walter, 2024). Furthermore, AI can support self-regulated learning by helping students monitor their understanding, seek clarification, evaluate information, and independently address learning difficulties (B. J. Chen et al., 2024; Yan et al., 2025). However, the functions and benefits of AI may vary according to students' learning needs and academic demands, indicate that AI utilization appears to vary alongside the academic demands encountered at different stages of study.

In chemistry education, AI has become an increasingly important component of modern scientific learning. It is recognized as one of the most significant technological advancements due to its strong applications in chemical research (Berber et al., 2025). In learning contexts, AI supports laboratory activities, data analysis (Iyamuremye et al., 2024), report writing, and scientific literature search (Tassoti, 2024). Its integration into learning processes has been shown to enhance conceptual understanding, laboratory competencies, and broader academic skills (Al Dokali et al., 2023). Patterns of AI utilization among students are closely related to the academic structure of the curriculum they experience.

In the present study, curriculum structure is operationally represented by curriculum stages associated with student cohorts (2021-2025), reflecting differences in course composition, laboratory intensity, academic assignments, and research involvement throughout the undergraduate chemistry program. Each stage of study is characterized by distinct academic demands. Introductory courses emphasize foundational conceptual understanding and adaptation to university learning systems, whereas advanced levels involve more complex laboratory work, data analysis, research activities, seminars, and scientific writing. Consequently, students encounter different learning needs across curriculum stages. These variations in learning formats, assignment types, laboratory intensity, and academic workload may contribute to differences in AI utilization patterns among students. Students may therefore use AI for different purposes depending on the academic demands encountered at each stage of study (L. Chen et al., 2020).

Numerous studies have examined the use of AI in education. However, most previous research has focused on students' perceptions (Al Dokali et al., 2023; Mendez, 2024; Sakhiyya et al., 2025), the benefits of AI usage (Nguyen, 2023), or the general challenges of implementing AI in learning environments (Nguyen, 2023; Yotov et al., 2026). These studies have largely examined students as a single group and rarely considered differences across stages of study. Research on AI utilization has also been conducted mainly in general higher education contexts, while discipline-specific evidence, particularly in chemistry education, remains limited. Most studies also tend to treat AI usage as a uniform phenomenon without considering how variations in learning structures, assignment types, laboratory intensity, and research involvement may shape students' academic needs. As a result, empirical evidence on how AI utilization varies across curriculum stages in chemistry education remains limited.

Based on these considerations, this study was conducted to explore AI utilization among chemistry students and examine its association with curriculum characteristics and academic demands across different student cohorts. This study focuses not only on the level of AI usage but also on variations in AI utilization across curriculum stages in relation to students' academic experiences. To guide the analysis, this study addresses the following research questions:

RQ1. How does the intensity of AI utilization vary across chemistry student cohorts?

RQ2. Which AI platforms are most commonly used at different curriculum stages?

RQ3. How do the purposes of AI use vary across curriculum stages in response to differing academic demands?

The findings of this study are expected to provide insights into how chemistry students use AI at different stages of their studies and support the development of AI literacy aligned with curriculum needs.

Method

This study implemented a descriptive quantitative approach using a survey method. This approach was used to describe patterns of AI utilization among chemistry students and to examine variations in AI use across curriculum characteristics and academic demands at different stages of study.

The population of this study consisted of all active students in the Department of Chemistry from 2021 to 2025 cohorts at Universitas Negeri Padang. The total number of students in each cohort is presented in Table 1 to provide an overview of population distribution and sample coverage.

The sample was determined using purposive sampling technique, in which respondents were selected based on specific inclusion criteria to ensure alignment with the objectives of the study. The criteria for respondents were: (1) active students of the Department of Chemistry at UNP, and (2) had experience using AI platforms in their academic activities.

Based on these criteria, a total of 162 students were selected as the research sample. The distribution of respondents by cohort is presented in Table 1.

Table 1. Distribution of Research Samples by Cohorts

Cohort	Current Semester (Curriculum)	Number of Respondents	Percentage (%)
2021	Semester 9 (Final Stage / Research)	24	14.8%
2022	Semester 7 (Advanced Stage / Research)	10	6.2%
2023	Semester 5 (Intermediate / Core Stage)	28	17.3%
2024	Semester 3 (Intermediate / Core Stage)	38	23.5%
2025	Semester 1 (Initial / Foundational Stage)	62	38.2%
	Total	**162**	**100%**

Differences in the number of respondents across cohorts were influenced by students' voluntary participation rates and the varying numbers of active students in each cohort during the data collection process. This imbalance in sample size should be considered when interpreting the results, particularly in relation to percentage stability and comparisons across cohorts, as smaller groups may produce more fluctuating percentage distributions.

The instrument used in this study was an online questionnaire developed using Google Form based on the objectives of the research and supported by previous studies on AI utilization in higher education. The questionnaire consisted of closed-ended questions with two response formats: single-response questions and multiple-response questions. Single-response questions were used to obtain specific information, whereas multiple-response questions were designed to identify various forms of AI utilization in students' academic activities.

The questionnaire was structured into three main dimensions: (1) frequency and intensity of AI usage, (2) types of AI platforms used, and (3) purposes of AI utilization in academic activities. The frequency dimension was measured using a single-response item asking respondents how often they used AI tools for academic purposes, with response categories ranging from "Rarely" to "Very Frequently." The AI platform and usage-purpose dimensions were measured using multiple-response items, allowing respondents to select more than one option. The platform dimension included tools such as ChatGPT, Google Gemini, Perplexity AI, Microsoft Copilot, and chemistry-specific AI applications. The purpose dimension covered various academic activities, including understanding concepts, summarizing learning materials, completing assignments, searching for references, preparing presentations, conducting simulations, and supporting research-related activities.

The questionnaire items were developed based on previous research on generative AI use in educational settings and were adapted to the context of chemistry learning. To enhance content appropriateness and item clarity, the instrument underwent expert review by lecturers in the Department of Chemistry, and revisions were made accordingly. Future research may extend the instrument development process by incorporating psychometric analyses, including validity and reliability assessments, to further substantiate the robustness of the measurement framework.

The research data were collected through the online distribution of questionnaires to students of the Chemistry Study Program using Google Form. The data collection process was conducted during the odd semester of the 2025/2026 academic year, from October to November. The questionnaire link was distributed through official student communication channels, including class WhatsApp groups.

Before participating, respondents were informed about the purpose of the study and provided informed consent at the beginning of the questionnaire. Participation was voluntary, and anonymity was ensured by not collecting any personal identifiers such as names or student identification numbers. To minimize duplicate responses, the Google Form was restricted to one response per Google account.

The collected data were analyzed using descriptive quantitative statistics in the form of frequencies, percentages, and cross-tabulations based on student cohorts. This analysis was conducted to identify trends in AI utilization patterns at different stages of study and to compare variations in AI usage across cohorts.

Meanwhile, data regarding the types of AI platforms and the purposes of AI utilization were analyzed using a multiple-response analysis approach because respondents were allowed to select more than one answer for each question item. Therefore, the percentages were calculated based on the number of respondents within each cohort, not on the total number of responses. Consequently, the sum of percentages for all options within a cohort may exceed 100%The percentage for each option was calculated using the following formula:

$$P = \frac{f}{n_{cohort}}\ x\ 100\%$$

P : Percentage proportion of responses for a particular option (%)
F : Frequency (number of clicks) for the option in each cohort
n_{respon} : Total number of individual respondents in that specific cohort (e.g., n = 24 for the 2021 cohort). (Sugiyono, 2013:134)

Results and Discussion

A. Curriculum Description and Course Distribution in the Department of Chemistry at UNP

The curriculum structure in the Department of Chemistry at UNP is systematically organized through course packages distributed across each semester. Each stage of study has distinct characteristics in terms of learning materials, learning outcomes, and competency focuses aligned with students' academic development. The course structure is designed to develop mastery of fundamental concepts as well as analytical and applied competencies in chemistry. An overview of the course distribution and competency focuses of Chemistry students at UNP across different cohorts is presented in Table 2.

The curriculum mapping presented in this study is based on official curriculum documents of the Chemistry Study Program at Universitas Negeri Padang (UNP) and curriculum information available on the official UNP curriculum system (kurikulum.unp.ac.id) and is interpreted to represent progressive stages of student competency development across semesters.

Table 2. Mapping of Curriculum Phases and Course Characteristics of the UNP Chemistry Department

Curriculum Phase	Semester / Cohort	Representation of Core Courses	Learning Characteristics and Academic Demands
Phase 1: Strengthening Foundational Sciences	Semesters 1-2	General Chemistry, Basic Chemistry, Mathematics for Chemistry, General Biology, General Physics, English for Chemistry, Basic Chemistry Laboratory.	Focused on mastering basic chemical concepts, calculation skills, understanding material structures at the microscopic level, as well as developing laboratory skills and basic report writing.
Phase 2: Deepening Concepts and Chemical Analysis	Semesters 3-4	Analytical Chemistry 1-2, Organic Chemistry 1-2, Physical Chemistry 1-2, Structure and Reactivity of Inorganic Compounds, Basics of Inorganic Reactions, Chemical Thermodynamics, Instructional Media and IT, Evaluation of Chemistry Learning.	Students begin to focus on analyzing more complex concepts, interpreting experimental data, strengthening laboratory skills, and integrating concepts across different fields of chemistry.
Phase 3: Development of Academic and Professional Competencies	Semesters 5-6	Organic Chemistry 3, Physical Chemistry 3, Instrumental Analysis, Research Methodology, Seminar on Chemistry/Chemistry Education, Laboratory for Biotic and Abiotic Systems, Microteaching, Educational Statistics, Environmental Chemistry, Molecular Biochemistry, Industrial Visit.	Learning emphasizes scientific analysis skills, research design formulation, academic communication, problem-solving, and strengthening professional competencies in accordance with the field of study.

Phase 4: Culmination and Science Implementation	Semesters 7-8	Undergraduate Thesis / Final Project, Educational Field Practice (PLK), Internship/MBKM (Independent Campus), Seminar on Chemistry Literature.	Students are required to work independently through research, scientific literature review, field implementation of competencies, and the integration of chemical knowledge to solve both academic and professional problems.

The data presented in Table 2 indicate that the curriculum in the Department of Chemistry at UNP is systematically structured in accordance with students' competency development at each stage of study. Early semesters are primarily directed toward strengthening fundamental concepts through courses emphasizing theoretical understanding, calculation skills, and basic laboratory competencies. After this foundation is established, learning gradually develops toward analytical abilities, interpretation of experimental data, and more advanced laboratory skills.

In the final semesters, students are no longer limited to studying concepts, but are also expected to apply them in research activities, scientific writing, and the independent resolution of chemical problems. This curriculum structure demonstrates a gradual progression from the mastery of fundamental concepts toward analytical and academic research competencies.

B. Patterns of AI Utilization Across Curriculum Stages

Based on survey results involving 162 respondents, chemistry students' academic activities can no longer be separated from the role of AI technology. Empirical evidence from the study showed that none of the respondents (0%) selected the category of never using AI in general. (Figure 1). This finding serves as a strong indicator that all research participants had been exposed to AI technology, regardless of cohort differences.

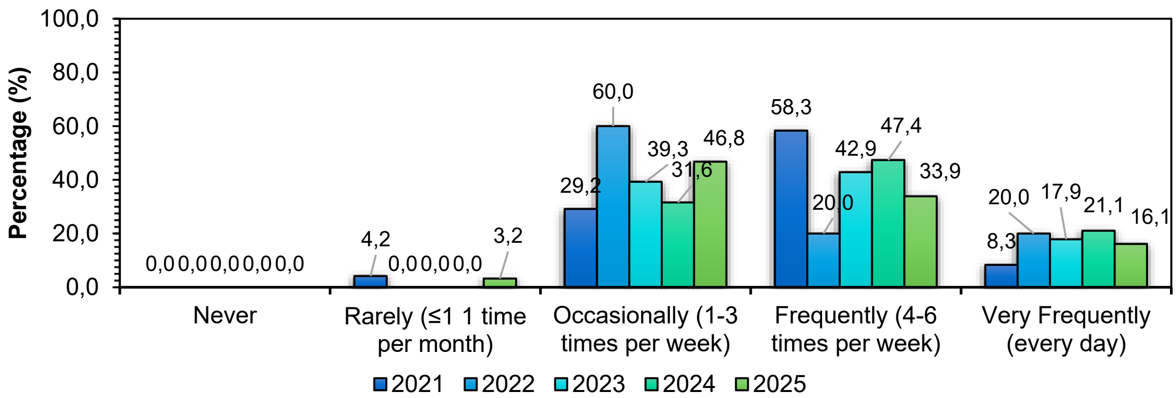

Figure 1. Percentage of AI Usage Frequency

In general, AI utilization among students was dominated by the categories of occasional and frequent use. These findings indicate that the intensity of AI usage varies among students. Such differences are likely related to academic needs, types of assignments, and individual learning habits.

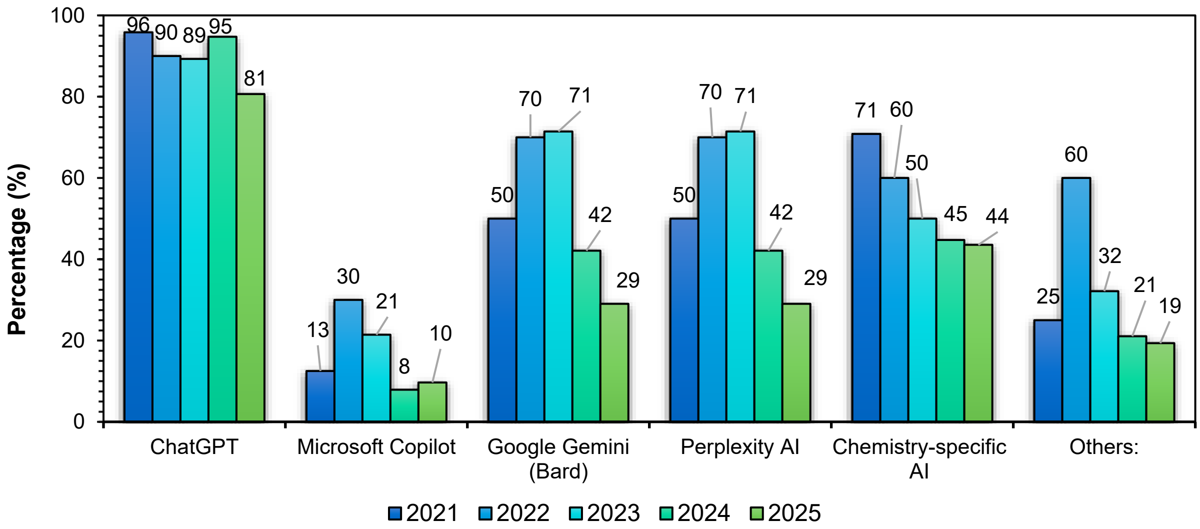

Figure 2. Percentage of Various AI Platforms Usage (Data are based on multiple-response choices, where percentages are calculated relative to the total number of respondents within each annual cohort.)

In addition to usage frequency, the variety of AI platforms utilized by students also demonstrated relatively diverse patterns. Based on the analysis of multiple-response questionnaire data, a total of 432 responses were recorded for AI platform types and 566 responses for the purposes of AI utilization from 162 students. The difference in response volume empirically indicates that students in the Department of Chemistry at UNP adopt multi-platforming and multi-tasking patterns to meet curriculum demands.

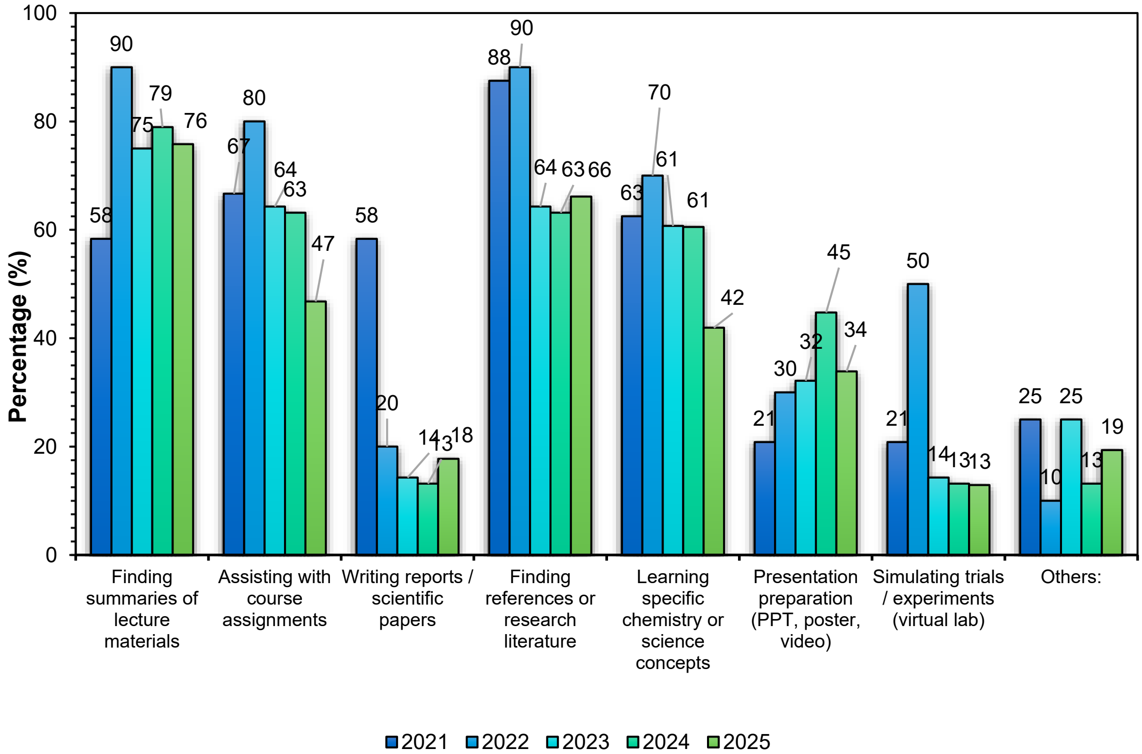

Figure 3. Percentage of AI Usage Purposes (Data are based on multiple-response choices, where percentages are calculated relative to the total number of respondents within each annual cohort.)

In general, ChatGPT was identified as the most dominant platform across all periods, maintaining a high penetration rate that ranged from 81% in 2025 to 96% in 2021. Meanwhile, Perplexity AI and Google Gemini both demonstrated a notable upward trend in early cohorts, peaking at 71% of respondents in 2023, particularly as students entered academic stages that emphasize analytical activities and scientific literature exploration, before declining to 29% in 2025. In addition to general generative AI, chemistry-specific platforms (e.g., MolView and ChemAI) also held a significant share, utilized by 71% of respondents in 2021 and maintaining a 44% adoption rate by 2025. The use of these specialized platforms may reflect students' needs for molecular visualization and laboratory learning support (Al Dokali et al., 2023).

Although the questionnaire did not explicitly examine the motivational factors underlying platform selection, the observed distribution of platform usage suggests a possible alignment between tool characteristics and students' academic tasks. ChatGPT was consistently used for general academic support, while Perplexity AI and Google Gemini were more frequently used during tasks involving information search and literature exploration. Similarly, chemistry-specific platforms such as MolView were mainly used for molecular visualization tasks that are difficult to perform using general-purpose AI tools. This interpretation is supported by previous studies suggesting that students tend to select AI tools based on their functional affordances and academic task requirements (Santos et al., 2026). The relationship between platform functionalities and academic purposes is further summarized in Table 3.

Differences in AI platform preferences can be interpreted through the technical affordances and distinct features offered by each platform, which align with students' intended purposes in their academic activities. Since the survey did not explicitly probe the qualitative motives behind platform choices, this relationship is conceptually synthesized and supported by existing literature in Table 3.

Table 3. Potential Alignment with Academic Tasks

AI Platform Type	Main Feature Characteristics	Observed Academic Use	Supporting Literature
ChatGPT	Possesses flexible generative *Natural Language Processing* (NLP) capabilities for explaining materials, summarizing texts, generating responses, and providing step-by-step explanations.	Commonly used for finding lecture material summaries, understanding basic concepts, assisting with assignments, and supporting independent learning.	Chan & Hu (2023); Javaid et al. (2023); Al-Obaydi and Pikhart (2026); Kasneci et al. (2023)
Microsoft Copilot	Integrated with the Microsoft ecosystem and supports document processing, web-based information retrieval, and basic academic writing assistance.	Used to assist document preparation, quick information searches, and daily academic productivity.	Adetayo et al. (2024); Fluker et al. (2025); Osadcha et al. (2024); Esfandiari and Allaf-Akbary (2025); Al-Obaydi and Pikhart (2026)
Google Gemini (Bard)	Connected directly to Google services with real-time information retrieval, text translation, and multimodal information processing capabilities.	Used for searching additional information, translating foreign literature, and supporting general academic reference searches.	Imran & Almusharraf, (2024); Bin Akhtar (2024); Supriyadi and Pahmi (2024); Al-Obaydi and Pikhart (2026);
Perplexity AI	AI-powered search engine capable of providing direct sources and scientific reference links.	Related to research reference searching, scientific literature exploration, and academic information verification.	Aydin (2024); Manik et al. (2025); Sari and Asmara (2025); Osadcha and Osadcha (2025)

Chemistry-Specific AI (ChemAI, MolView, etc.)	Equipped with molecular structure visualization, compound simulation, spectroscopy interpretation, and spatial chemistry modeling features.	Used to support understanding of abstract chemistry concepts, molecular visualization, reaction mechanism interpretation, and laboratory or research activities.	Al Dokali et al. (2023); Iyamuremye et al. (2024); Berber et al. (2025); Sayed, J (2026); Mendez (2024)
Others	Includes various other AI platforms used according to students' specific academic needs.	Used for additional purposes not fully accommodated by the main AI platforms, such as specific information retrieval or technical assistance.	

The findings of this study indicate that the intensity of AI utilization, the purposes of its use, and the selection of AI platforms tend to change in accordance with the learning characteristics at each stage of study. These differences can be observed through variations in AI usage frequency across cohorts, which are closely related to the academic demands of each curriculum phase.

During the initial stage of study (2025 cohort), the intensity of AI utilization appeared relatively high in terms of regular weekly engagement, as evidenced by the frequency data in Figure 1. Data shows that 46.8% of the 2025 cohort interacts with AI "Occasionally" (1-3 times per week) and 33.9% "Frequently" (4-6 times per week). While their daily usage (Very Frequently at 16.1%) is slightly lower than the 2024 cohort (21.1%), their overall weekly footprint indicates a highly routine integration. This condition is closely associated with the demands of first-semester courses, which are still dominated by the strengthening of fundamental science and chemistry concepts, such as Basic Chemistry, Mathematics for Chemistry, General Biology, General Physics, and Basic Chemistry Laboratory. These courses require students to understand abstract fundamental concepts, particularly microscopic representations of matter, stoichiometry, atomic structure, chemical bonding, and various mathematical calculations that form the foundation of advanced chemistry learning.

The specific driver behind this high weekly frequency is explicitly mapped in Figure 3, where a striking 76% of the 2025 cohort utilizes AI for finding summaries of lecture materials and 66% for finding references or research literature. Conversely, their reliance on AI for high-level academic output remains minimal, with only 18% using it for writing reports or scientific papers-starkly contrasting with the senior 2021 cohort which stands dominant at 58% for report writing. This quantitative contrast suggests that early-year students tend to use AI primarily as support for conceptual understanding. To support this intensive conceptual bridging, data from Figure 2 confirms that 81% of these freshmen heavily depend on ChatGPT for language-based explanations, complemented by a substantial 44% adoption rate of chemistry-specific AI platforms.

At this stage, students are in the early phase of higher education, where learning activities are primarily focused on building foundational understanding of basic chemistry concepts, supporting numerical exercises, and developing basic laboratory skills. The survey results indicate that AI use at this stage is mainly associated with supporting lecture comprehension and assisting students in understanding fundamental concepts.

The dominance of ChatGPT usage during this phase indicates that students primarily require platforms capable of providing simple and interactive language-based explanations. ChatGPT's Natural Language Processing features help students understand difficult concepts through step-by-step explanations, simple analogies, and examples of problem-solving procedures (Morbidoni et al., 2026). This pattern is especially evident in courses such as Mathematics for Chemistry and Basic Chemistry, which involve extensive numerical exercises and conceptual reasoning.

In addition, the use of chemistry-specific AI platforms such as MolView and similar applications has also begun to emerge to support the visualization of concepts that are difficult to observe directly (Elyasova, 2024). In Basic Chemistry and Basic Chemistry Laboratory courses, students begin studying molecular shapes, compound geometry, orbitals, and atomic interactions at the microscopic level. Therefore, AI-based molecular visualization assists students in developing better spatial understanding of the structures and properties of chemical compounds (Kuit & Osman, 2021), which serve as the foundation for subsequent chemistry learning.

As students enter the phase of deepening chemical concepts and analysis (2024 cohort), the intensity of AI utilization remains relatively high, although the patterns of usage begin to change. At this stage, students start taking courses that emphasize analytical skills, data interpretation, and the interconnection of chemical concepts, such as Analytical Chemistry 1-2, Organic Chemistry 1-2, Physical Chemistry 1-2, Structure and Reactivity of Inorganic Compounds, Fundamentals of Inorganic Reactions, and Chemical Thermodynamics. The characteristics of these courses no longer focus solely on understanding fundamental theories, but also require students to explain chemical phenomena scientifically and quantitatively.

These changes in learning characteristics may be associated with the purposes of AI utilization. Students begin using AI to assist with laboratory data interpretation, understanding organic reaction mechanisms, explaining relationships between thermodynamic and kinetic concepts, and analyzing laboratory experimental results.

In Organic Chemistry courses, for example, AI is utilized to support the understanding of reaction mechanism stages, functional group transformations (Hallal et al., 2023), and the visualization of complex compound structures (Harsini Shakarami, 2025). Meanwhile, in Analytical Chemistry and Physical Chemistry, students more frequently use AI to assist in interpreting data, understanding graphs (Cardoso Rial, 2024), and explaining mathematical relationships and abstract theoretical concepts. At this stage, ChatGPT remains the dominant platform, but increased usage of Google Gemini and Perplexity AI also becomes evident. This shift is associated with students' growing need for scientific references and more specific information (Marisa et al., 2025). Students no longer require only simplified explanations, but also rapid access to theories, scientific data, and reference sources that can support laboratory reports and analytical assignments. The web-based search features available in Gemini and Perplexity help students obtain additional sources more efficiently, particularly when preparing the discussion sections of laboratory reports.

Furthermore, the intensity of AI utilization at this phase may be explained by the high frequency of laboratory work and weekly report writing. The increasingly complex academic workload causes AI to function not only as a learning support tool, but also as an academic analysis support tool. Students utilize AI to connect theoretical concepts with experimental findings, explain chemical phenomena observed in laboratory activities, and strengthen scientific arguments in laboratory reports.

Subsequently, during the phase of developing academic and professional competencies (2023 cohort), AI utilization patterns become more specific according to students' academic needs. Courses such as Instrumental Analysis, Research Methodology, Molecular Biochemistry, Educational Statistics, and Environmental Chemistry increasingly demand deeper scientific thinking skills. At this stage, students are not only required to understand concepts, but also to develop research designs, review scientific literature, interpret instrumental data, and present analytical findings academically. Consequently, AI utilization becomes more directed toward searching for scientific references, developing research ideas, interpreting instrumental data, and assisting with the preparation of presentations and academic reports. For example, in Instrumental Analysis courses, students are introduced to the interpretation of spectra and laboratory instrument data, which require both theoretical understanding and analytical reasoning simultaneously. Meanwhile, in Research Methodology and Chemistry Seminar courses, AI begins to be utilized to assist in identifying research topics, organizing proposal frameworks, and locating supporting references from various scientific sources. At this stage, the use of Perplexity AI and Google Gemini tends to increase because students require access to more up-to-date scientific references directly connected to literature sources (Marisa et al., 2025; Yan et al., 2025). On the other hand, ChatGPT continues to be utilized, but primarily as a support tool for academic writing, scientific sentence construction, and the simplification of difficult concepts. The use of chemistry-specific AI platforms also becomes more evident, particularly among students who begin engaging in laboratory research and require assistance with molecular visualization and more specialized chemical data interpretation.

Meanwhile, during the culmination and scientific implementation phase (2022 and 2021 cohorts), students are more heavily involved in undergraduate thesis preparation, literature seminars, educational field practice, internships, and MBKM activities. These activities require greater engagement with independent learning, research-related tasks, and the application of chemistry knowledge in academic and professional contexts. The survey results suggest that AI use at this stage is commonly associated with activities such as searching for research literature, supporting academic writing, and assisting with research-related tasks. In addition, the relatively high use of chemistry-specific AI platforms among senior cohorts may reflect the need for tools that support molecular visualization, spectroscopy interpretation, and the analysis of chemistry-related information. These findings are consistent with previous studies reporting the use of AI to support scientific writing, literature exploration, and research activities in higher education (Rodafinos, 2025; Yan et al., 2025).

The observed patterns across cohorts suggest that AI utilization may vary according to the academic demands encountered at different stages of study. However, because this study employed a descriptive design, these patterns should not be interpreted as evidence of causal relationships between curriculum stages and AI use. Instead, the findings provide an overview of how AI utilization appears to align with students' learning needs and academic activities across the curriculum.

Table 4 presents an interpretive synthesis of the observed patterns of AI utilization across curriculum stages. The framework is derived from the descriptive findings and supported by relevant literature. It is intended as a conceptual representation of how AI functions appear to correspond to students' learning needs at different stages of study rather than as a statistically validated model.

Table 4. Summary of AI Utilization Patterns Across Curriculum Phases

Study Stage (Cohort)	Core Curriculum Characteristics	Dominant AI Platforms	Dominant Academic Uses (Interpretive Synthesis Based on Survey Data)
Foundational Phase (2025 Cohort)	Strengthening abstract science baselines, extensive numerical exercises, basic lab literacy.	ChatGPT (81%), Chemistry-specific AI (44%).	Scaffolding & Simplification: High weekly frequency for lecture synthesis (76%) and conceptual reasoning; translating abstract micro-structures.
Analytical Phase (2024 Cohort)	Quantitative reasoning, interconnection of chemical concepts, heavy weekly lab reports.	ChatGPT, Google Gemini (42%), Perplexity AI (42%).	Data Interpretation & Integration: Transitioning to discussion drafting, exploring mechanisms, and linking data to thermodynamic/kinetic theories.
Competency Phase (2023 Cohort)	Research methodology, instrumental spectral analysis, advanced biochemistry.	Google Gemini (71%), Perplexity AI (71%), Chemistry-specific AI (45%).	Literature Synthesis & Evaluation: Searching up-to-date scientific references (63%) and developing initial research designs/frameworks.
Culmination Phase (2022 & 2021 Cohorts)	Undergraduate thesis, independent research, professional field practice.	ChatGPT (90-96%), Chemistry-specific AI (50-71%).	Academic Production & Refinement: Highly selective purpose-driven use; spectrum analysis, advanced mechanism visualization, and scientific manuscript polishing.

Overall, the findings indicate that AI utilization among chemistry students at Universitas Negeri Padang differs across cohorts. Variations were observed in the frequency of AI use, platform preferences, and academic purposes of utilization. These differences appear to correspond with variations in learning characteristics and academic demands represented by different curriculum stages. While the present study does not establish causal relationships, the findings suggest that students tend to use AI in ways that align with the academic tasks and learning activities they encounter throughout their studies. Consequently, AI serves a range of functions, from supporting conceptual understanding in the early stages of study to assisting with literature exploration, academic writing, and research-related activities in later stages.

Conclusion

This study found that AI was widely utilized among chemistry students across all cohorts at Universitas Negeri Padang. Occasional and frequent use represented the dominant patterns of AI utilization, although variations in usage intensity were observed across cohorts. ChatGPT emerged as the most frequently used AI platform, while the use of Google Gemini, Perplexity AI, and chemistry-specific AI tools varied across curriculum stages. Differences were also observed in the purposes of AI use. Students in the early stages of study primarily reported using AI to support conceptual understanding and learning activities, whereas students in later stages more frequently used AI for literature exploration, academic writing, laboratory-related tasks, and research support. Overall, the findings provide a descriptive overview of how AI utilization patterns differ across curriculum stages in chemistry education.

The observed variations in AI utilization suggest that AI integration strategies may benefit from being aligned with students' academic needs across different stages of study. The findings may inform the development of stage-appropriate AI literacy initiatives in chemistry education, including responsible AI use, critical evaluation of AI-generated information, academic integrity, and the effective use of discipline-specific AI tools to support learning and research activities.

The findings should be interpreted in light of several methodological considerations. The study employed purposive sampling and relied on self-reported questionnaire data collected from a single institution, with unequal cohort representation. Furthermore, the analysis was limited to descriptive statistics and was not intended to examine relationships among variables or establish causal explanations. Accordingly, the results should be viewed as a contextual description of AI utilization patterns within the study setting. Future research may extend this work through larger and more diverse samples, multi-institutional investigations, validated measurement instruments, and inferential or longitudinal approaches to provide a more comprehensive understanding of AI utilization in chemistry education.

References

Adetayo, A. J., Aborisade, M. O., & Sanni, B. A. (2024). Microsoft Copilot and Anthropic Claude AI in education and library service. *Library Hi Tech News*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/LHTN-01-2024-0002

Al Dokali, N., Aljarmi, A., & Baroud, N. (2023). *Artificial Intelligence in Chemistry Classrooms: Student Perceptions, Learning Outcomes, and Theoretical-Practical Integration*. *4*(2), 140–154. https://jurnal.uinsyahada.ac.id/index.php/Lavoisier/index

Al-Obaydi, L. H., & Pikhart, M. (2026). The use of Copilot, Gemini and ChatGPT in the context of foreign language learning and teaching: An academic technology review. *Contemporary Educational Technology*, 18(2), ep640. https://doi.org/10.30935/cedtech/18056

Aydin, Ö. (2024). Google Gemini, ChatGPT, and Perplexity: A comparative analysis of AI tools for academic literature searching. *The Journal of Academic Librarianship*, 50(2), 102856. https://doi.org/10.1016/j.acalib.2024.102856

Berber, S., Brückner, M., Maurer, N., & Huwer, J. (2025). Artificial Intelligence in Chemistry Research─Implications for Teaching and Learning. *Journal of Chemical Education*, *102*(4). https://doi.org/10.1021/acs.jchemed.4c01033

Bin Akhtar, Z. (2024). From bard to Gemini: An investigative exploration journey through Google's evolution in conversational AI and generative AI. *Computing and Artificial Intelligence*, *2*(1), Artikel 1378. https://doi.org/10.59400/cai.v2i1.1378

Cardoso Rial, R. (2024). AI in analytical chemistry: Advancements, challenges, and future directions. In *Talanta* (Vol. 274). https://doi.org/10.1016/j.talanta.2024.125949

Chen, B. J., Chen, C. M., & Huang, C. L. (2024). A Virtual 3D Chemistry Laboratory with an Enhanced AI Chatbot to Facilitate Learning Effectiveness. *Proceedings - 2024 16th IIAI International Congress on Advanced Applied Informatics, IIAI-AAI 2024*, *64*, 718–719. https://doi.org/10.1109/IIAI-AAI63651.2024.00151

Chen, L., Chen, P., & Lin, Z. (2020). Artificial Intelligence in Education: A Review. *IEEE Access*, *8*, 75264–75278. https://doi.org/10.1109/ACCESS.2020.2988510

Chan, C. K. Y., & Hu, W. (2023). Students' voices on generative AI: Perceptions, benefits, and challenges in higher education. *International Journal of Educational Technology in Higher Education*, 20(1), 43. https://doi.org/10.1186/s41239-023-00411-w

Elhag, A., Abri, A. M., & Fahmy Yousef, A. M. (2025). the Effect of Generative Ai Tools (Chatgpt, Gemini, Etc.) on Students' Achievement and Their Motivation Towards Learning. *Journal of Technology and Science Education*, *15*(3), 746–759. https://doi.org/10.3926/jotse.3410

Elyasova, J. (2024). The impact of molecular modeling and simulation technologies on students' conceptual understanding in chemistry education. *InterConf*, *60(260)*, 49–54.

https://doi.org/10.51582/interconf.19-20.08.2025.007

Esfandiari, R., & Allaf-Akbary, O. (2025). Assessing the impact of Microsoft Copilot and ChatGPT on EFL learners' interactional metadiscourse in argumentative writing. Innoeduca: *International Journal of Technology and Educational Innovation*, 11(1), 49–62. https://doi.org/10.24310/ijtei.111.2025.20896

Fernández-Batanero, J. M., Montenegro-Rueda, M., Fernández-Cerero, J., & López Menéses, E. (2024). Adoption of the Internet of Things in higher education: opportunities and challenges. *Interactive Technology and Smart Education*, *21*(2), 292–307. https://doi.org/10.1108/ITSE-01-2023-0025

Fluker, J., Murray, M. C., & Gupta, J. (2025). Preparing for the future: An initial examination of Generative AI's integration into Unified Communications through the lens of Microsoft Copilot in Teams. *Issues in Informing Science and Information Technology*, 22, 9. https://doi.org/10.28945/5514

Fuchs, K. (2024). Evaluating the academic utility of large language models: Google Gemini and ChatGPT in higher education contexts. *Computers and Education Open*, 6, 100175. https://doi.org/10.1016/j.caeo.2024.100175

Hallal, K., Hamdan, R., & Tlais, S. (2023). Exploring the potential of AI-Chatbots in organic chemistry: An assessment of ChatGPT and Bard. *Computers and Education: Artificial Intelligence*, *5*(July), 100170. https://doi.org/10.1016/j.caeai.2023.100170

Harsini Shakarami, S. (2025). " Integration of Artificial Intelligence in Organic Chemistry: Recent Advances, Applications, and Challenges." *International Journal of Modern Achievement in Science, Engineering and Technology (IJSET)*, *2*(2), 130–139. https://doi.org/10.63053/ijset.88

He Li, & Elvira S. Balinas. (2025). The Impact of Generative Artificial Intelligence on University Information Literacy Education: A Systematic Review from Challenges to Changes. *International Journal of Latest Technology in Engineering Management & Applied Science*, *14*(2), 25–38. https://doi.org/10.51583/ijltemas.2025.1402004

Imran, M., & Almusharraf, N. (2024). Google Gemini as a next generation AI educational tool: a review of emerging educational technology. *Smart Learning Environments*, *11*(1), Artikel 22. https://doi.org/10.1186/s40561-024-00310-z

Iyamuremye, A., Niyonzima, F. N., Mukiza, J., Twagilimana, I., Nyirahabimana, P., Nsengimana, T., Habiyaremye, J. D., Habimana, O., & Nsabayezu, E. (2024). Utilization of artificial intelligence and machine learning in chemistry education: a critical review. *Discover Education*, *3*(1). https://doi.org/10.1007/s44217-024-00197-5

Javaid, M., Haleem, A., Singh, R. P., Khan, S., & Khan, I. H. (2023). Unlocking the opportunities through ChatGPT Tool towards ameliorating the education system. *BenchCouncil Transactions on Benchmarks, Standards and Evaluations*, *3*(2), 100115. https://doi.org/10.1016/j.tbench.2023.100115

Kankeviciene, L., Gedviliene, G., & Supranaviciene, U. (2026). Integrating AI Tools Into Learning : A Study of Students ' Attitudes in Universities , Colleges , and Vocational Institutions. 28(1), 1–17. *European Journal of Open, Distance and E-Learning*, 28(1): 5, 1–17. https://doi. org/10.65043/eurodl.165

Kasneci, E., Sesartic, K.,. (2023). ChatGPT for good? On the impacts of generative artificial intelligence in education. *Education and Information Technologies,* 28(5), 5427–5451. https://doi.org/10.1007/s10639-023-11640-3

Kuit, V. K., & Osman, K. (2021). Chembond3d e-module effectiveness in enhancing students' knowledge of chemical bonding concept and visual-spatial skills. *European Journal of Science and Mathematics Education*, *9*(4), 252–264. https://doi.org/10.30935/SCIMATH/11263

Lorenzo-Lledó, A., & García, B. A. (2025). Ai and Iot in Education: Training for Industry 5.0 and Skills Development in the 21St Century. *Journal of Technology and Science Education*, *15*(3), 623–628. https://doi.org/10.3926/jotse.4119

Manik, D., Tanjung, Y. A., & Hartati, R. (2025). Integrating Perplexity AI into academic research: A study on research gap analysis and proposal development. *Fonologi: Jurnal Bahasa dan Sastra,* 3(4). https://doi.org/10.61132/fonologi.v3i4.2605

Marisa, M., Pertiwi, S., & Wahyuni, S. (2025). Utilization of Artificial Intelligence in Modern Education. *Jurnal Teknologi Pendidikan*, *2*(4). https://doi.org/10.47134/jtp.v2i4.1933

Mendez, J. D. (2024). Student Perceptions of Artificial Intelligence Utility in the Introductory Chemistry Classroom. *Journal of Chemical Education*, *101*(8). https://doi.org/10.1021/acs.jchemed.4c00075

Morbidoni, C., Mascitti, A., Sarra, A., Tonucci, L., & Coccia, F. (2026). Exploring the Potential of Using ChatGPT in Chemistry Education. *Journal of Chemical Education*, *103*(1), 286–297. https://doi.org/10.1021/acs.jchemed.5c00854

Nguyen, N. D. (2023). Exploring the role of AI in education. *London Journal of Social Sciences*, *6*, 84–95. https://doi.org/10.31039/ljss.2023.6.108

Osadcha, K., Szynkiewicz, J., & Chishti, M. S. (2024). Using Microsoft Copilot Chat in the work of IT educators: Pilot study. *NIKT: Norsk IKT-konferanse for utdanning*, (1). https://doi.org/10.5324/nikt.6202

Osadcha, K. P., & Osadcha, M. V. (2025). Experience of using the Perplexity AI-powered answering system for educational content generation. *Information Technologies and Learning Tools*, 105(1), 112–124. https://doi.org/10.33407/itlt.v105i1.5946

Rodafinos, A. (2025). The Integration of Generative AI Tools in Academic Writing: Implications for Student Research. *Social Education Research*, 250–258. https://doi.org/10.37256/ser.6220256517

Sakhiyya, Z., Trisanti, N., Affiliations, A., & Emails, A. (2025). The Students' Perceptions of Artificial Intelligence (AI) in Higher Education: A Systematic Literature Review. *Eltlt*, *14*, 182–195. https://proceeding.unnes.ac.id/eltlt

Santos, J. M., San Andres, T. C., Piad, K. C., Sharov, S., Santos, M. R. C., & Wider, W. (2026). Student integration of Artificial Intelligence (AI) tools in research: A framework-based analysis. International *Journal of Information and Education Technology*, 16(5), 1322–1336. https://doi.org/10.18178/ijiet.2026.16.5.2600

Sari, S. P., & Asmara, R. (2025). Pengaruh Perplexity Terhadap Pencarian Informasi Dalam Tugas Akademik Mahasiswa Perpustakaan dan Ilmu informasi Universitas Negeri Padang. *Jurnal Pustaka AI (Pusat Akses Kajian Teknologi Artificial Intelligence)*, 5(1), 71–75. https://doi.org/10.55382/jurnalpustakaai.v5i1.946

Sayed, J. (2026). AI Enhanced Organic Chemistry: Emerging Tools and Computational Strategies. *Global Trends in Science and Technology*, 2(1), 36–52. https://doi.org/10.70445/gtst.2.1.2026.36-52

Sugiyono. (2013). Metode penelitian pendidikan pendekatan kuantitatif, kualitatif, dan r&d. Bandung: Alfabeta.

Supriyadi, E., & Pahmi, S. (2024). Exploring the potential of AI tools in education: *A thematic analysis of Gemini.ai. Gema Wiralodra*, 15(3). https://doi.org/10.31943/gw.v15i3.771

Tassoti, S. (2024). Assessment of Students Use of Generative Artificial Intelligence: Prompting Strategies and Prompt Engineering in Chemistry Education. *Journal of Chemical Education*, *101*(6), 2475–2482. https://doi.org/10.1021/acs.jchemed.4c00212

Walter, Y. (2024). Embracing the future of Artificial Intelligence in the classroom: the relevance of AI literacy, prompt engineering, and critical thinking in modern education. *International Journal of Educational Technology in Higher Education*, *21*(1). https://doi.org/10.1186/s41239-024-00448-3

Yan, W., Nakajima, T., & Sawada, R. (2025). Beyond tool use: Tracking the evolution of generative AI literacy among university students through a process-oriented investigation. *Computers and Education: Artificial Intelligence*, *9*(September), 100465. https://doi.org/10.1016/j.caeai.2025.100465

Yotov K, Gaftandzhieva S, Hadzhikolev E, Hadzhikoleva S and Gorgorova M (2026) AI in education through the learners' eyes: practical experience, perceptions, and challenges. *Front. Educ.* 11:1717886. doi: 10.3389/feduc.2026.1717886