GenAI Evolution in Science & Engineering Education

How science and engineering students integrate generative AI tools throughout their four-year academic journey, based on survey data from 843 undergraduate students at the Technion.

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Survey Methodology

Timing

Fifth week of Winter semester

Participants

843 undergraduate students across four academic years

Focus

Usage frequency and educational purposes of GenAI tools

Analysis

Patterns across academic years and time periods

Survey Questions

Our 2024-2025 survey introduced two new questions to explore how Technion students integrate GenAI tools in their learning:

Question 1: Usage Frequency

Students reported how often they use GenAI tools (ChatGPT, Perplexity, Gemini) across three time periods:

- Previous academic year
- Current academic year
- Next academic year (projected)

Responses were measured on a four-point scale: Never, Seldom, Often, and Constantly.

Question 2: Educational Purposes

Students who indicated any level of GenAI usage were asked to specify their educational applications.

Analysis of GenAI Usage

1. Academic Journey Evolution

As undergraduate science and engineering students advance in their academic path, they become more and more comfortable integrating GenAI tools into their learning process.

2. Multi-Dimensional Growth

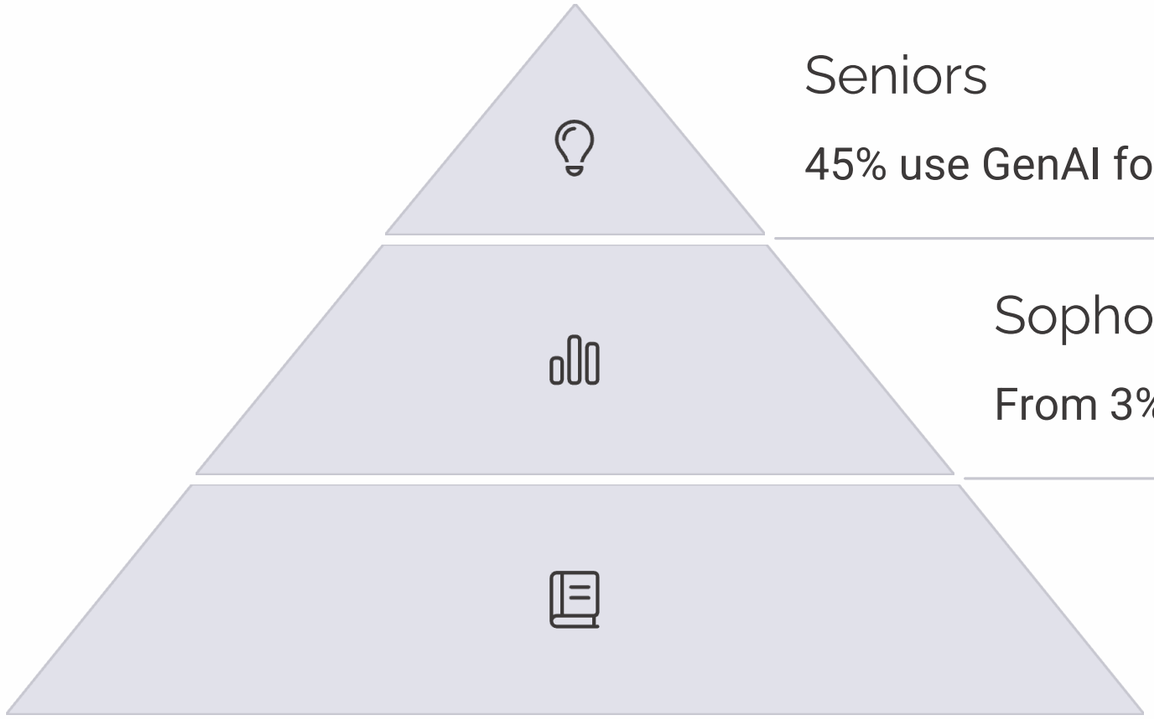
The students show increased sophistication in tool usage across years. their usage of GenAI tools increases along several dimensions: frequency, number of usages, meta-cognition, technical capabilities, and academic skills.

3. Accelerated Adoption

Students in advanced computational fields demonstrate faster adoption rates and more innovative applications of GenAI tools compared to their peers in other disciplines.

1. Academic Journey Evolution

Diversification of GenAI Usage



Seniors

45% use GenAI for multiple purposes

Sophomores & Juniors

From 3% to 10% use GenAI for 3+ purposes

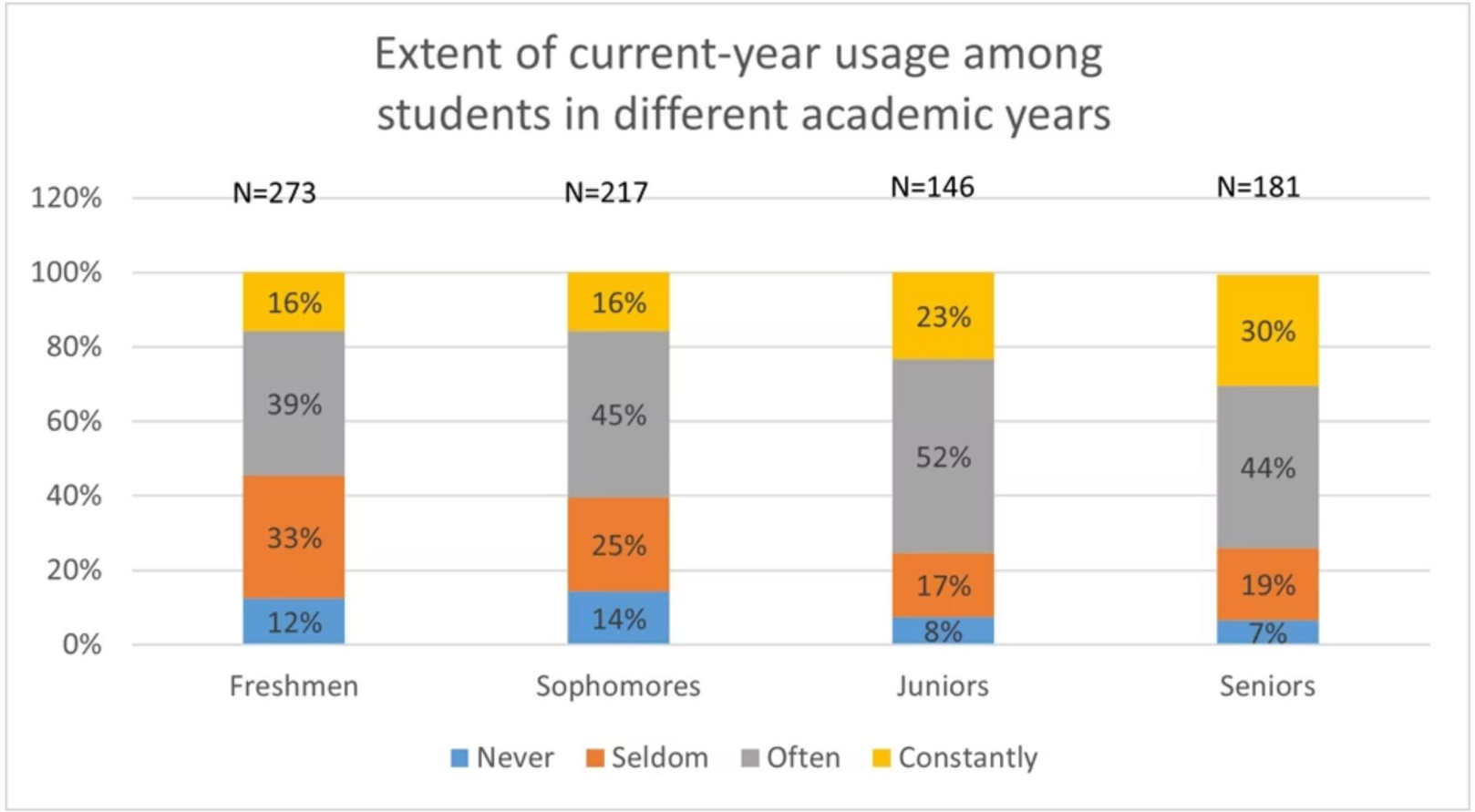
Freshmen

81% stick to a single use

As students progress through their academic journey, they tend to use GenAI for more and more purposes

1. Academic Journey Evolution

Frequency of Use for Various Cohorts, November 24



Students’ self-ranking of their use of GenAI in their current year of studies

1. Academic Journey Evolution

Increasing Adoption Across Academic Years

16%

Freshmen & Sophomores

First and Second year students using GenAI "constantly"

23%

Juniors

Third-year students using GenAI "constantly"

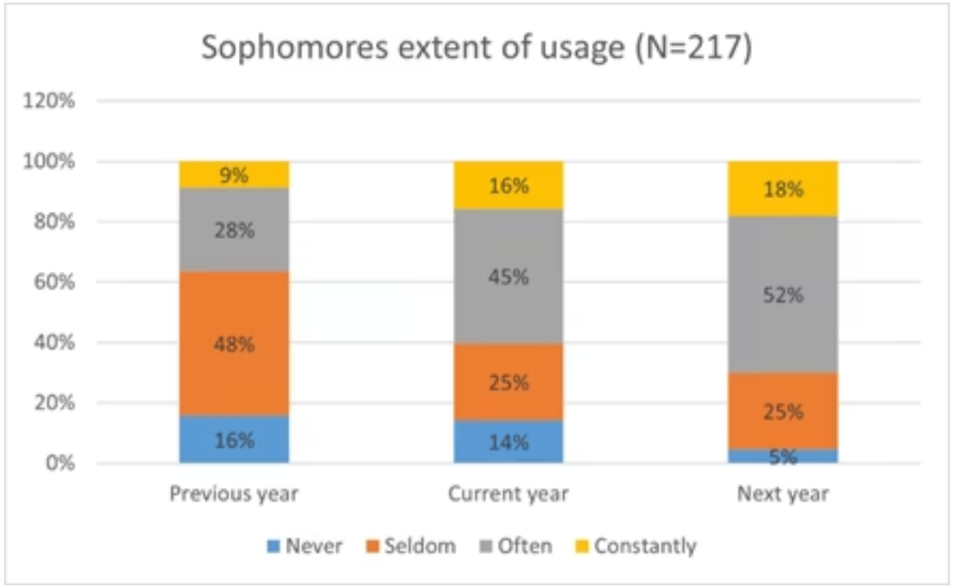
30%

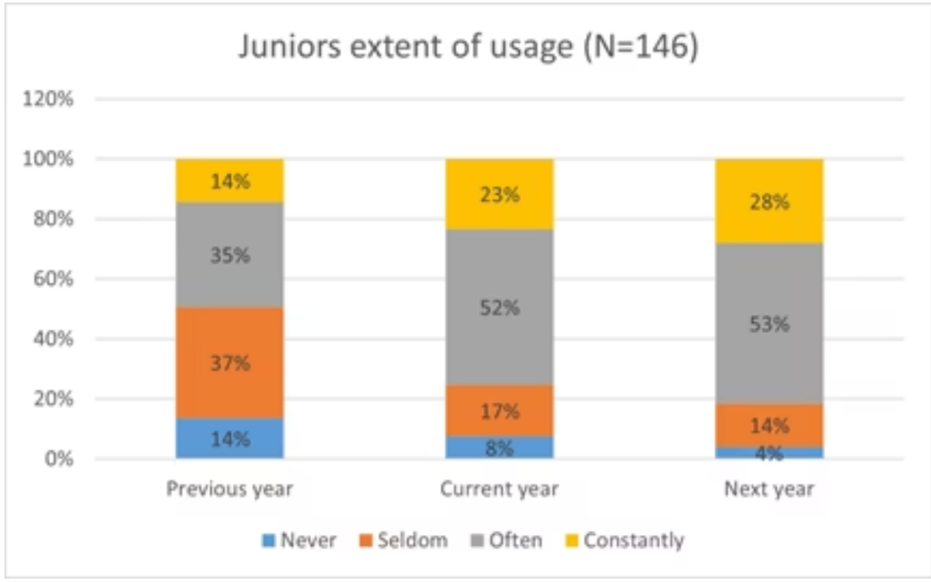
Seniors

Fourth-year students using GenAI "constantly"

1. Academic Journey Evolution

Usage in Three Time Periods





Students’ self-ranking of their use of GenAI in three time periods: Left- Sophomores; Right - Juniors

A consistent decline in the "never" and "seldom" categories was seen, alongside an increase in the "often" and "constantly" categories. This trend was mirrored across all academic years.

1. Academic Journey Evolution

Projected Future Usage

62%

First-Year Students

Projected regular usage next year

70%

Second-Year Students

Projected regular usage next year

81%

Third-Year Students

Projected regular usage next year

1. Academic Journey Evolution

Key Insights for Educators

1

Dynamic Integration

GenAI usage evolves significantly throughout academic years.

2

Fundamental Part

GenAI tools are becoming a fundamental part of how students learn and work.

3

Complementary Tools

GenAI complements rather than replaces traditional learning methods.

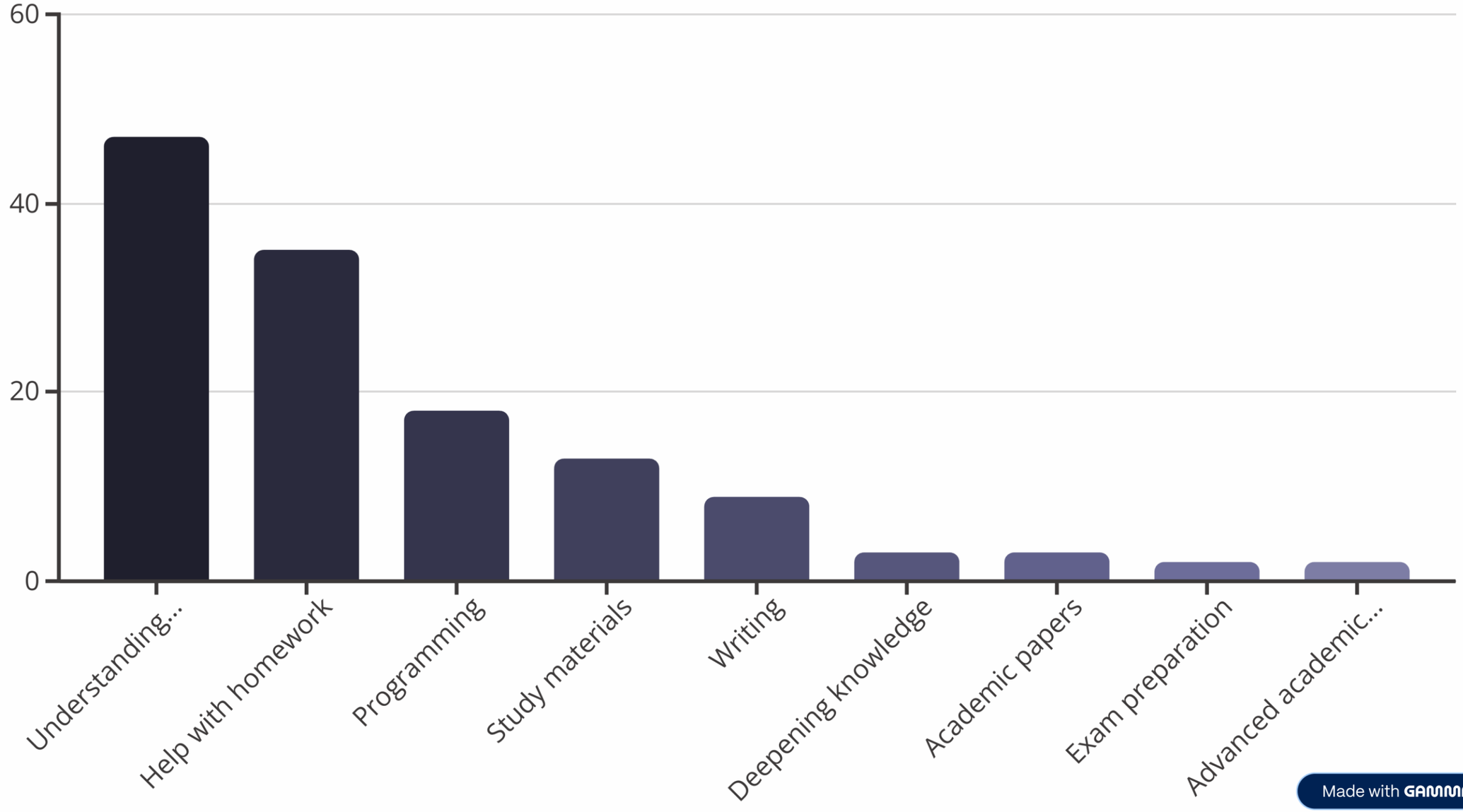
4

Tailored Approaches

One-size-fits-all policies may be less effective than year-specific guidelines.

2. Multi-Dimensional Growth

Categories of GenAI Usage



2. Multi-Dimensional Growth

Cohort Characterizations

Freshmen

Primarily use GenAI as a digital tutor, focusing on basic understanding (52%) and immediate academic needs. They seek direct help with homework (43%) and creation of learning materials (10%).

Few freshmen use GenAI for programming help (2%), and then mostly for basic syntax and simple debugging, reflecting their entry-level technical needs.

Typical questions: "Can you explain this concept?" or "What does this term mean?"

Sophomores

While understanding course material remains primary (52%), there's a shift toward more advanced applications, including "deepening knowledge" (6% vs. 1% for freshmen).
Students begin asking not just "what" but "why" and "how," and programming support increases (12% vs. 2% for freshmen), reflecting higher programming demands in second-year courses.

Typical approach: "When I'm having trouble with homework, I use tools that help me understand the way to a solution."

2. Multi-Dimensional Growth

Cohort Characterizations

Juniors Specialization & Seniors Sophistication

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Programming Support

Increases from 27% (juniors) to 36% (seniors) with focus on advanced challenges

Academic Papers

New category for juniors (7%) and seniors (8%) for paper analysis and literature review

Advanced Academic Activities

Emerges in juniors (5%) and seniors (3%) for innovative ideas and complex thinking

While understanding course material remains significant for both juniors (42%) and seniors (40%), their usage patterns show a clear evolution toward more sophisticated applications. Seniors appear to be at the forefront of GenAI adoption, integrating these tools as an integral part of their learning experience and adjusting usage to meet specific academic needs.

2. Multi-Dimensional Growth

Key Trends Across Multiple Dimensions

Meta-Cognition

Evolution from seeking direct answers (freshmen) to cross-referencing and verifying GenAI responses (seniors)

Technical Capabilities

Progression from basic syntax questions to complex system design challenges

Academic Skills

Advancement from seeking direct answers to leveraging GenAI for research, analysis, and creative projects

Freshmen quote: "To explain homework questions if I didn't understand the question, to give hints for the solution, and sometimes to solve and correct my solutions."
Senior quote: "I usually check with it to see if I was right about the question if there is no reference, and help with summarizing articles and such. Of course, I check everything myself."

2. Multi-Dimensional Growth

Key Trends Across Multiple Dimensions

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Academic Skills

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Freshmen quote: "Help in writing code and especially in debugging it (sometimes as a duck).”

Senior quote: "Help with programming homework, code debugging, learning new programming libraries. Help in creating graphs and visualizing results.”

2. Multi-Dimensional Growth

Key Trends Across Multiple Dimensions

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Technical Capabilities

Progression from basic syntax questions to complex system design challenges

Academic Skills

Advancement from seeking direct answers to leveraging GenAI for research, analysis, and creative projects

Freshmen quote: "Explanations for topics I don't understand, various refinements. Sometimes help solving homework and exam preparation.”.

Senior quotes: "For drafting purposes, consultation on issues in the study material.”

"To evolve and get better ideas for projects, we use it when we have an idea but are looking to make it more creative and also to learn how to do technical things such as [implement] APA [standards for] papers.”

2. Multi-Dimensional Growth

Conclusion & Implications

Dynamic Evolution

Undergraduate science and engineering students' usage of GenAI tools is not static but evolves over time across multiple dimensions: frequency, variety, sophistication, meta-cognition, technical capabilities, and academic skills.

Differentiated Support

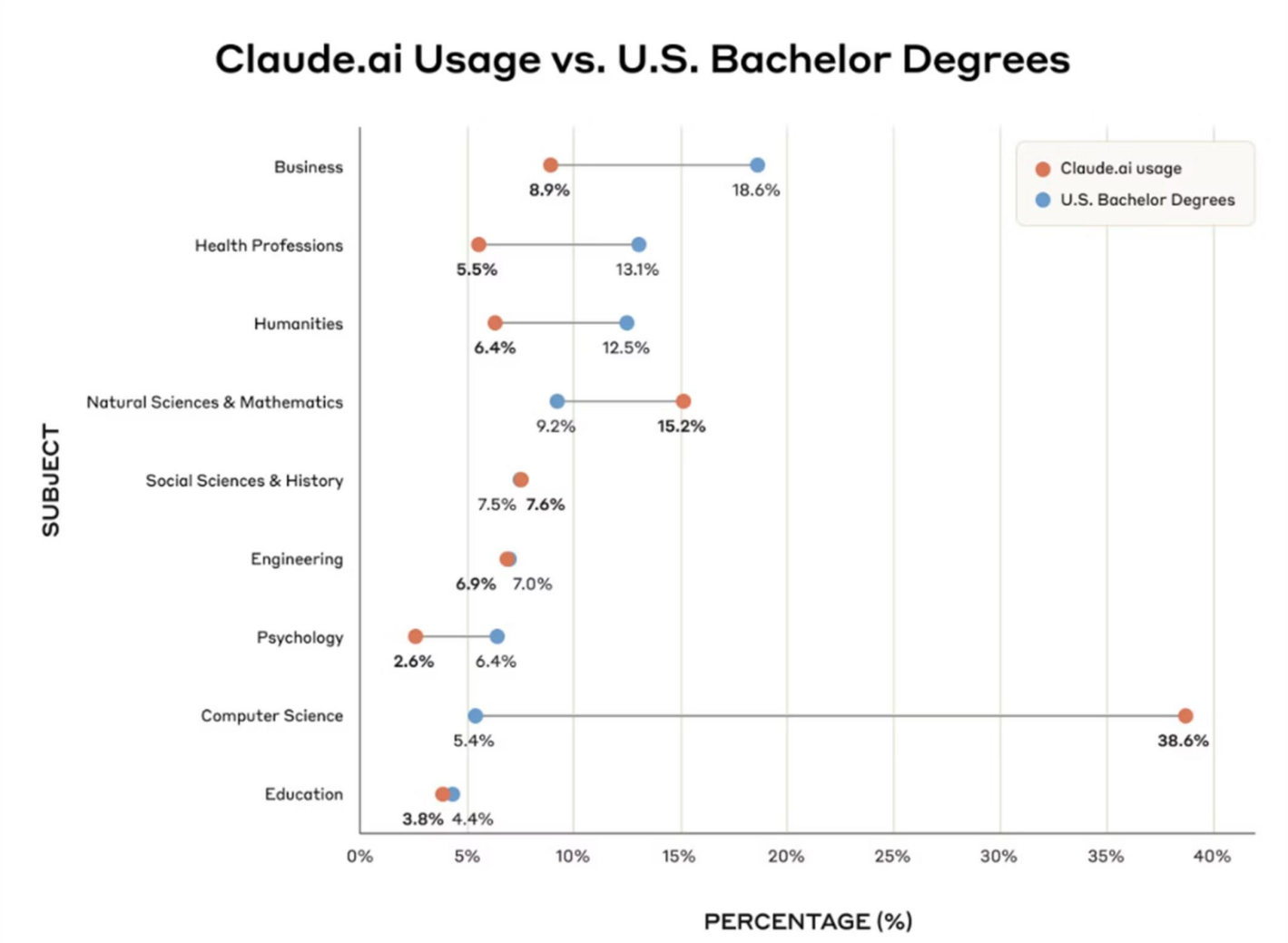
This evolution suggests a need for differentiated educational frameworks and regulations to support and guide students at different stages of their academic journey.

Enhanced Learning Potential

The spontaneous development of these usage patterns suggests that formal recognition and guidance could further enhance their impact on student learning outcomes.

Imagine how these usages could have been further enhanced to impact students' learning, had they been acknowledged, recognized, and included in the study guidance students receive when they enter academia.

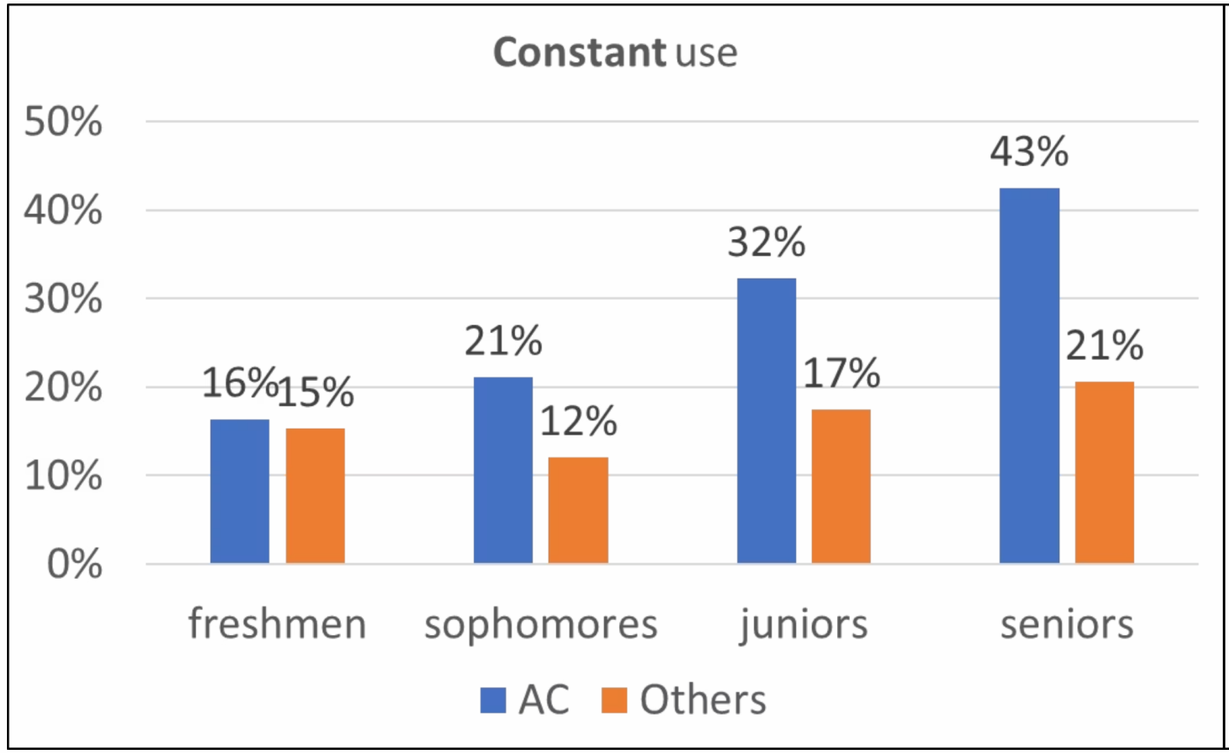
3. Accelerated Adoption

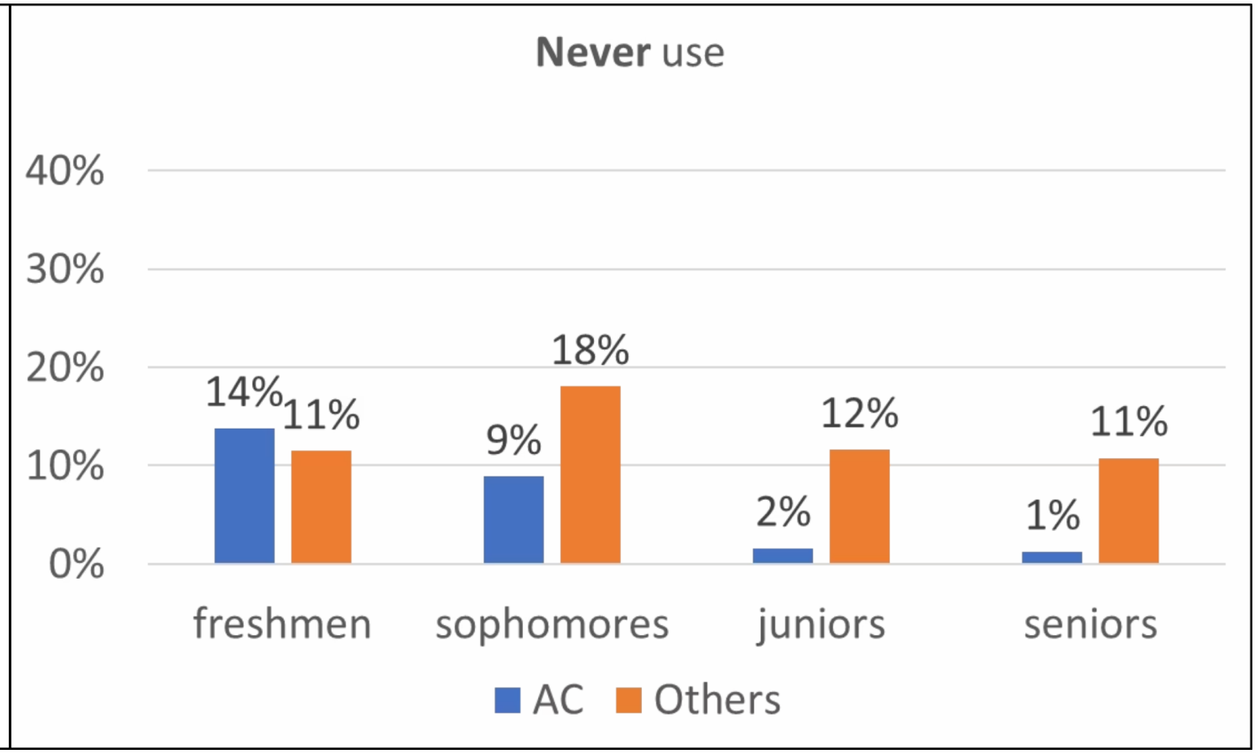


Anthropic Education Report: How University Students Use Claude Apr 8, 2025

3. Accelerated Adoption

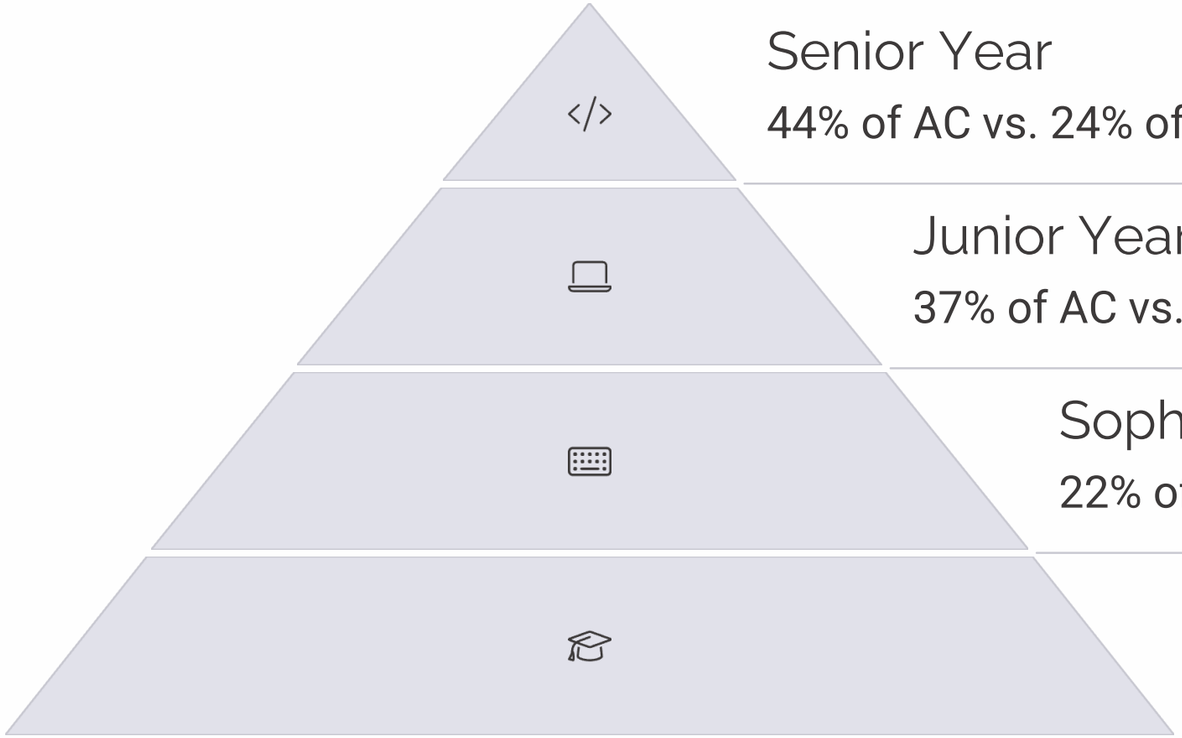
Adoption Rates: AC vs. Other STEM Students





3. Accelerated Adoption

Programming Assistance



Senior Year

44% of AC vs. 24% of other STEM

Junior Year

37% of AC vs. 21% of other STEM

Sophomore Year

22% of AC vs. 8% of other STEM

Freshman Year

9% of AC vs. 2% of other STEM

The most striking difference between AC and other STEM students appears in programming-related GenAI usage. The gap widens significantly as students progress, starting at a 7% point difference in freshman year and expanding to a 20% point difference by senior year.

This growing divergence reflects the code-oriented nature of AC studies and demonstrates how GenAI tools transition from being learning scaffolds to becoming practical resources that advanced students integrate into their workflow.

3. Accelerated Adoption

Evolution of GenAI Usage Categories

Early Years: Foundation Building

First and second-year students primarily use GenAI for understanding course material (52-66% for AC students) and homework help (33-40% for AC students). Usage patterns between AC and other STEM students are relatively similar at this stage.

Middle Years: Specialization

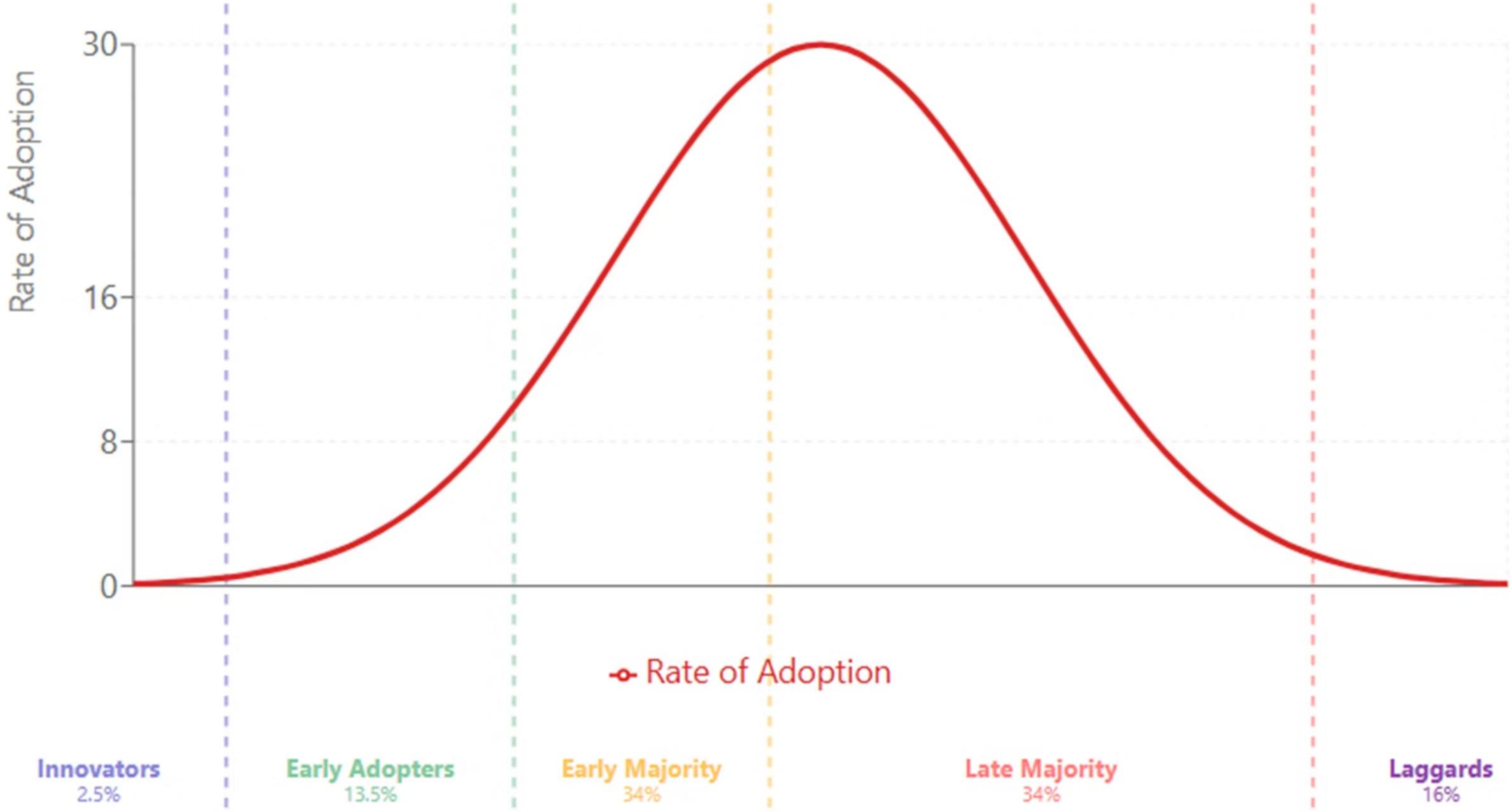
By junior year, AC students show distinct specialization in programming assistance (37% vs. 21% for other STEM). Other STEM students begin diversifying their usage across study materials (21%) and writing assistance (14%).

Senior Year: Advanced Integration

Senior AC students show sophisticated integration of GenAI, with 44% using it for programming and 20% for writing assistance. Other STEM seniors distribute usage more evenly across understanding material (33%), programming (24%), and writing (22%).

3. Accelerated Adoption

Rogers' Diffusion of Innovation theory (2003)



3. Accelerated Adoption

Accelerated Early Adopters: Theoretical Framework

Supportive Role

The percentage of AC students that use GenAI to understand course material is 66% for freshmen and 48% for seniors, compared with 49% and 33% for freshmen and seniors of other disciplines, respectively. This can be explained by the more demanding learning material in AC fields

Practical Resources

The percentage of AC students that use GenAI for programming is 37% for juniors and 44% for seniors, compared with 24% for seniors of other disciplines. This evolution reflects the code-oriented nature of AC studies, an area in which GenAI tools excel

Building on Rogers' Diffusion of Innovation theory (2003), our data suggests AC students represent a distinct category of "accelerated early adopters." Their technical background and immediate practical applications for GenAI create a feedback loop that drives increasingly sophisticated usage.

This pattern extends beyond mere frequency of use to encompass depth and complexity of GenAI applications, particularly in programming contexts where these tools excel.

3. Accelerated Adoption

Pedagogical Implications and Recommendations

Leverage Existing Adoption

Instructors in AC fields can build on students' natural inclination to use GenAI by redesigning learning tasks to emphasize debugging, code comprehension, and computational thinking.

Create Adoption Roadmaps

The patterns observed in AC students can serve as templates for creating scaffolded experiences in other disciplines, gradually building confidence and competence with GenAI tools.

Foster Digital Literacy

Rather than restricting GenAI, educators should design tasks that encourage collaborative learning with AI partners while promoting critical reflection on these tools' strengths and limitations.

As GenAI tools become increasingly integrated into academic environments, educational approaches must evolve accordingly. By understanding the accelerated adoption patterns of AC students, we can design more effective learning experiences across all disciplines.

The goal should be to prepare all students to engage critically and productively with AI technologies, developing skills that will serve them throughout their academic and professional careers.

Summary

Academic Journey Evolution

GenAI adoption increases with academic progression, showing distinctly higher and more complex usage patterns throughout the educational journey.

Multi-Dimensional Growth

Usage expands across task complexity, tool sophistication, and application diversity.

Accelerated Adoption

AC students represent "accelerated early adopters," creating opportunities for innovative pedagogical approaches that leverage GenAI as a learning partner.

Key Takeaways

- GenAI adoption follows predictable patterns that can inform educational design
- Technical disciplines show accelerated integration of AI tools
- Educators should embrace rather than restrict these tools