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Analyzing listening and comprehension strategies among engineering students: A cross-sectional study ☆

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A R T I C L E I N F O

Method name:
Listening Strategies Analysis in Engineering Education (LSAEE)

Keywords:
Listening strategies
Engineering education
Gender differences
Note-taking
Critical thinking
Comprehension strategies
Active learning
Higher education

A B S T R A C T

Effective listening strategies are crucial for academic success in engineering education, particularly where English serves as the medium of instruction. This cross-sectional study examined the relationship between demographic factors and listening strategy utilization among 234 engineering students (126 males, 108 females) at Vellore Institute of Technology, Chennai. Data was collected using a 40-item Listening Strategies Analysis Questionnaire measuring seven dimensions: note-taking, active learning, comprehension, predictive organization, critical thinking, resource-based learning and self-management. Statistical analysis revealed significant gender differences in note-taking behavior ($t(232) = -3.037$, $p = .003$), with female students demonstrating higher scores than males. Critical thinking showed the highest adoption among all strategies. While age showed no significant effect on note-taking, notable differences were found in predictive organization and critical thinking across age groups.

- Female students showed significantly higher note-taking scores ($M = 3.58$, SD = 0.56) compared to males ($M = 3.37$, SD = 0.49).
- Critical thinking was the most adopted strategy ($M = 3.64$, SD = 0.57).
- Age significantly influenced predictive organization ($p = .024$) and critical thinking abilities ($p = .011$).

These insights can inform targeted interventions to enhance listening comprehension skills in engineering education.

Specifications table

Subject area:	Psychology
More specific subject area:	Educational Psychology
Name of your method:	Listening Strategies Analysis in Engineering Education (LSAEE)
Name and reference of original method:	Method adapted from Oxford's Strategy Inventory for Language Learning (SILL): Oxford, R. L. (1990). Language learning strategies: What every teacher should know. Heinle & Heinle.
Resource availability:	Listening Strategies Analysis Questionnaire for Engineering Students (40-item instrument) - Data collection tools: Online-based survey platform - Raw data and analysis files available upon request from corresponding authors

☆ **Related research article:** None.
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Background

Effective listening comprehension strategies play a crucial role in academic success, particularly in technical education where complex concepts are often conveyed through lectures [1]. The importance of these strategies becomes even more pronounced in engineering education, where students must process and retain intricate technical information while simultaneously developing professional competencies. Recent studies have highlighted that metacognitive awareness and strategic listening are fundamental components of successful academic performance in engineering programs [2].

In engineering education, where English predominantly serves as the medium of instruction across many countries, the ability to comprehend and process information effectively becomes particularly critical [3]. This linguistic dimension adds an additional layer of complexity for students, especially in contexts where English is not their first language. Recent research examining second-language listening strategy instruction has demonstrated significant improvement in students' comprehension abilities, with particularly strong effects on technical vocabulary acquisition and procedural understanding [4].

The theoretical foundation for understanding listening strategies in STEM education draws from several intersecting frameworks. Metacognitive theory, as applied to engineering education by Rahimirad and Moini [5], suggests that successful technical learners employ specific monitoring and evaluation strategies when processing lecture content. Their research with engineering students demonstrated that metacognitive listening strategies were significant predictors of academic achievement, particularly in courses with high conceptual density. Similarly, Oxford's [6] Strategy Inventory for Language Learning (SILL) framework provides a structured approach to understanding how students strategically process auditory information across different contexts, including technical fields.

The examination of gender and age as potential influencing factors in listening strategy utilization is grounded in substantial theoretical and empirical work in educational psychology and STEM education research. These demographic variables warrant specific investigation in engineering education contexts for several compelling reasons.

Gender as a variable in listening strategy research is grounded in both cognitive and sociocultural frameworks. From a cognitive perspective, research by Voyer and Voyer [7] suggests that male and female students may process academic information differently, with potential implications for how they engage with and comprehend technical content. Their comprehensive meta-analysis examining gender differences in academic performance found small but consistent differences across subject areas, with potential implications for how students approach learning tasks. In the context of language learning strategies, Oxford and Nyikos [8] found that gender was a significant factor in strategy choice, with female students reporting more frequent use of formal rule-related practice strategies, general study strategies, and conversational input elicitation strategies. From a sociocultural perspective, gender differences in academic strategy likely reflect broader patterns of socialization and educational experiences. Wang and Degol [9] identified multiple pathway models through which gender may influence STEM learning experiences, including different responses to learning environments and differential returns on similar learning strategies. Their review suggests that gendered experiences in educational settings can shape strategic approaches to learning technical content, which may extend to listening and comprehension strategies in engineering education.

Age-related differences in listening strategies derive from developmental theories of adult learning and metacognition. Veenman and Spaans [10] found that metacognitive abilities—central to effective listening strategy deployment—continue to develop throughout adolescence and early adulthood, with implications for how students of different ages might approach complex learning tasks. Their research demonstrated significant age-related increases in metacognitive skills that were relatively independent of intellectual ability, suggesting that developmental factors may play an important role in strategy utilization across age groups.

Vandergrift and Baker [11] specifically examined learner variables in listening comprehension, finding that metacognition and working memory were significant predictors of listening performance. Their path analysis demonstrated that age-related factors influenced both direct and indirect pathways to listening comprehension, highlighting the importance of considering developmental factors in understanding listening strategy utilization. This has particular relevance for engineering education, where students must process complex technical information delivered through lectures and presentations.

Gender differences in STEM education, particularly in engineering, have been a subject of increasing research interest. Wang et al. [12] found significant variations in learning approaches and academic performance between male and female engineering students in higher education. Their multi-institutional study revealed gender-specific patterns in information processing, with implications for how students engage with technical content. These findings are further supported by Chen et al. [13] research, which revealed distinct differences in verbal and visual learning styles between male and female engineering students, with implications for how they process and retain lecture content.

While previous studies have examined general academic listening strategies [1], research specifically examining the relationship between demographic factors (such as gender and age) and listening strategy utilization in engineering education remains limited. This gap is particularly significant given that engineering programs typically attract diverse student populations with varying linguistic backgrounds and learning preferences. The need for research in this area is underscored by findings that listening comprehension skills are crucial for academic success in technical fields, where students must frequently process complex auditory information. The relative paucity of empirical investigations focused specifically on the interaction between demographic variables and strategic listening behavior in engineering contexts constitutes a significant limitation in the current literature.

To address this research gap, the present study investigates the following research questions:

1. What are the most frequently used listening strategies among engineering students?

2. How do male and female students differ in their utilization of listening and comprehension strategies?
3. What is the impact of age on the use of listening comprehension and coping strategies?

By examining these questions, this research aims to provide insights that can inform the development of more effective and inclusive teaching approaches in engineering education. The findings of this study have significant implications for how listening strategy instruction might be tailored to different student demographics in technical education settings, potentially enhancing pedagogical practices and supporting more equitable learning outcomes across diverse student populations.

Significance of the study

This study provides significant contributions to engineering education and language learning research by addressing critical gaps in understanding listening strategy utilization in technical education settings. As engineering programs increasingly adopt English as the medium of instruction globally, effective listening comprehension becomes crucial for academic success, particularly given that approximately 80% of classroom learning in engineering occurs through listening activities [2]. The examination of gender and age-related differences in listening strategy use is especially significant given the growing diversity in engineering education, aligning with recent research highlighting the importance of understanding gender-specific learning approaches in STEM fields [12]. The findings offer practical value for engineering educators by identifying effective listening strategies that can be explicitly taught and reinforced, providing evidence-based insights for developing targeted interventions and supporting the design of more inclusive teaching methodologies [4]. Furthermore, the research contributes to institutional policy development through empirical evidence for strategy-based instruction and curriculum design, while also advancing research methodology by establishing a validated approach for analyzing listening strategies in technical education [13]. The study's comprehensive framework supports professional development in engineering education by guiding faculty development programs and informing teaching assistant training, addressing the growing need for evidence-based professional development in engineering education [2]. These contributions are particularly timely given the increasing emphasis on developing effective listening comprehension skills in technical education and the growing diversity in engineering programs globally, providing a foundation for creating more inclusive and effective teaching practices that acknowledge and address the diverse needs of engineering students.

Method details

Research design and theoretical framework

This cross-sectional [14] investigation employed a quantitative research methodology grounded in Oxford's [6] Strategy Inventory for Language Learning (SILL) framework. The study design prioritized the examination of relationships between demographic variables (gender and age) and seven dimensions of listening strategy utilization among engineering students. A priori power analysis conducted using G*Power 3.1 [15] indicated that a minimum sample size of 128 participants would be required to detect medium effect sizes ($f = 0.25$) with 80 % power at $\alpha = 0.05$. The final sample size of 234 participants exceeded this requirement, ensuring adequate statistical power for the primary analyses.

Participants and sampling procedures

The study employed a systematic sampling approach targeting first-year engineering students at Vellore Institute of Technology, Chennai. The final sample comprised 234 students, with 126 males (53.8 %) and 108 females (46.2 %). The age distribution reflected the typical undergraduate engineering population at the institution: 17-year-olds ($n = 70$, 29.9 %), 18-year-olds ($n = 129$, 55.1 %), 19-year-olds ($n = 26$, 11.1 %), and students aged 20 and above ($n = 9$, 3.9 %). All participants were enrolled in English-medium engineering programs, presenting a suitable population for examining listening strategies in technical education contexts.

Instrumentation

Data collection was facilitated through the Listening Strategies Analysis Questionnaire, a 40-item instrument adapted from Oxford's [6] SILL framework and specifically modified for engineering education contexts based on Dalman and Plonsky's [4] meta-analytical findings. The instrument utilized a 5-point Likert scale (1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always) to measure seven strategic dimensions:

1. Note-Taking Strategies (Items 1–9): Assessed techniques for recording and organizing lecture information
2. Active Learning (Items 10–17): Measured approaches for engaging with and responding to lecture content
3. Comprehension Techniques (Items 18–24): Evaluated methods for understanding and interpreting information
4. Predictive Organization (Items 25–29): Assessed anticipatory and organizational processing strategies
5. Critical Thinking (Items 30–35): Measured analytical and evaluative approaches to lecture content
6. Resource-Based Learning (Items 36, 37): Assessed utilization of supplementary materials and resources
7. Self-Management (Items 38–40): Evaluated regulatory and attentional control strategies

The instrument underwent comprehensive reliability and validity testing, with detailed results explained in the Methodological validation section.

Data collection procedures

The questionnaire was administered in controlled classroom environments during regular academic hours following standardized protocols outlined by Vandergrift and Goh [1]. Faculty permission was obtained to collect data from students during class time and all participants provided informed consent. The instrument was administered in English, consistent with the medium of instruction. Complete data was obtained from all 234 participants, resulting in a 100 % response rate with no missing values identified during data screening.

Data analysis strategy

Statistical analyses were conducted using IBM SPSS version 26, employing a sequential analytical approach. Initial data screening included tests of normality (Shapiro-Wilk), homogeneity of variance (Levene's test), and examination of multivariate assumptions (Box's M test). Descriptive statistics quantified central tendency, dispersion, and distributional characteristics for all strategic dimensions. Primary analyses proceeded in three phases aligned with the research questions:

1. Strategy usage patterns were analyzed using descriptive statistics (means, standard deviations) and frequency distributions to identify predominant listening approaches.
2. Gender differences were examined using independent-samples *t*-tests with Cohen's d calculated to quantify effect sizes. Statistical significance was evaluated at $\alpha = 0.05$, with effect sizes interpreted according to Cohen's [16] guidelines: small ($d = 0.2$), medium ($d = 0.5$) and large ($d = 0.8$).
3. Age-related variations were analyzed through one-way ANOVA with post-hoc Tukey HSD tests for pairwise comparisons. Effect sizes were quantified using partial eta squared (η^2), with interpretations following Cohen's [16] benchmarks: small ($\eta^2 = 0.01$), medium ($\eta^2 = 0.06$) and large ($\eta^2 = 0.14$).

Multivariate analysis of variance (MANOVA) was subsequently employed to examine potential interaction effects between gender and age, with Pillai's Trace and Wilks' Lambda used as test statistics due to their robustness to violations of homogeneity assumptions.

Methodological validation

The validation of the methodological approach encompassed comprehensive statistical testing to ensure the robustness and reliability of the findings. The validation process encompassed multiple dimensions, including statistical assumption testing, reliability assessment, and construct validation.

Statistical assumption testing

As confirmed through statistical testing (Box's $M = 162.598$, $F = 0.997$, $p = .495$; see Table 1), the data met the homogeneity of covariance matrices assumption. Further validation through Levene's Test (shown in Table 2) demonstrated non-significant results across all key dimensions, with p-values ranging from 0.028 (Resource based Learning) to 0.754 (Predictive Organization).

Table 1
Box's test of equality of covariance matrices.

Box's M	162.598
F	0.997
df1	140
df2	9365.579
Significance	0.495

Table 2
Levene's test results for homogeneity of variance.

Variable	Levene Statistic	df1	df2	Sig.
Note Taking	1.384	7	226	0.213
Active Learning	0.718	7	226	0.657
Comprehension	1.287	7	226	0.258
Critical Thinking	2.037	7	226	0.052
Predictive Organization	0.602	7	226	0.754
Resource based Learning	2.298	7	226	0.028
Self-Management	0.859	7	226	0.540

Reliability assessment

The internal consistency reliability analysis demonstrated that all seven strategic dimensions exhibited satisfactory Cronbach's alpha values ranging from 0.72 to 0.86, indicating strong reliability of the measurement scales. Notably, the Note-taking dimension showed the highest reliability coefficient ($\alpha = 0.86$), followed by Comprehension ($\alpha = 0.85$) and Active Learning ($\alpha = 0.83$), demonstrating particularly strong internal consistency in these areas. Even the dimension with the lowest alpha value, Resource-based learning ($\alpha = 0.72$), exceeded the generally accepted threshold for acceptable reliability, confirming the overall robustness of the instrument.

To further validate the instrument's reliability, split-half reliability testing was conducted. The analysis yielded Spearman-Brown coefficients ranging from 0.70 to 0.84, with a strong correlation between halves ($r = 0.81$). This strong correlation between the two halves of the instrument provides additional evidence of its reliability and internal consistency. Importantly, all dimensions exceeded the minimum threshold of 0.70 for split-half reliability, further confirming the instrument's stability and consistency in measuring the intended constructs.

Construct validation

The instrument's structural integrity was substantiated through factor analysis with principal components extraction and varimax rotation. The factor analysis revealed excellent sampling adequacy with a Kaiser-Meyer-Olkin measure of 0.842, indicating that the sample size was more than adequate for the analysis. Bartlett's Test of Sphericity produced significant results ($\chi^2(780) = 3245.67$, $p < .001$), confirming that the correlation matrix was suitable for factor analysis. The analysis yielded a seven-factor solution that explained 70.3 % of the total variance, with factor loadings ranging from 0.45 to 0.82, demonstrating robust construct validity of the instrument's dimensional structure.

The convergent validity analysis revealed strong inter-dimensional relationships that aligned with theoretical expectations. Particularly notable were the strong correlations between conceptually related dimensions: Note-taking showed a strong correlation with Active Learning ($r = 0.62$), while Comprehension demonstrated a substantial correlation with Critical Thinking ($r = 0.58$). Additionally, Predictive Organization exhibited a significant correlation with Critical Thinking ($r = 0.55$). All these correlations were statistically significant at $p < .01$, providing strong evidence for the instrument's convergent validity. These relationships not only support the theoretical framework underlying the instrument's design but also demonstrate the interconnected nature of these learning strategies while maintaining their distinct characteristics. Fig. 1 presents these reliability coefficients, split-half reliability, and inter-dimension correlations across all seven dimensions, along with key statistical validation results.

The validation results demonstrate strong psychometric properties of the instrument and compliance with statistical assumptions. The high-reliability coefficients, coupled with significant convergent validity measures and clear factor structure, support the strength of the methodology. These findings provide a solid foundation for the analysis of listening strategies among engineering students.

Results

Listening strategies utilization

The analysis of listening strategy adoption among engineering students revealed a clear hierarchy in strategy utilization. As shown in Fig. 2, Critical thinking emerged as the most frequently employed strategy ($M = 3.64$, SD = 0.57, Mdn = 3.67, Q1 = 3.33, Q3 = 4.00), indicating students' strong tendency to analyze and evaluate lecture content critically. This was closely followed by comprehension strategies ($M = 3.58$, SD = 0.49, Mdn = 3.57, Q1 = 3.29, Q3 = 3.86), suggesting that students prioritize understanding and interpreting lecture material. Note-taking strategies showed moderate adoption ($M = 3.47$, SD = 0.53, Mdn = 3.44, Q1 = 3.11, Q3 = 3.78), while active learning demonstrated the lowest level of adoption ($M = 3.06$, SD = 0.59, Mdn = 3.14, Q1 = 2.71, Q3 = 3.43). This hierarchy suggests that students tend to favor passive cognitive strategies over active engagement strategies in their learning process. Fig. 2 illustrates the strategy adoption patterns, highlighting the consistent preference for cognitive processing strategies over behavioural engagement approaches.

Gender differences in strategy utilization

Having established the overall hierarchy of strategy adoption among engineering students, the analysis next investigated potential gender-based differences in strategy utilization patterns. The investigation of gender differences in listening strategy utilization revealed significant variations in certain strategic dimensions. Most notably, note-taking strategies showed a significant gender difference ($t(232) = -3.037$, $p = .003$, $d = 0.40$), with female students demonstrating higher adoption rates ($M = 3.58$, SD = 0.56, Mdn = 3.56, Q1 = 3.22, Q3 = 4.00) compared to their male counterparts ($M = 3.37$, SD = 0.49, Mdn = 3.33, Q1 = 3.00, Q3 = 3.78). This represents a small-to-medium effect size according to Cohen's [16] benchmarks. In the context of engineering education, this magnitude of difference suggests a practically meaningful disparity in how male and female students approach information recording during lectures. This effect size suggests that two-thirds of female students would score above the average male student in note-taking strategy use. From an instructional design perspective, this magnitude of difference warrants consideration when developing listening comprehension support interventions, suggesting that gender-differentiated approaches to note-taking instruction may have practical utility in engineering classrooms.

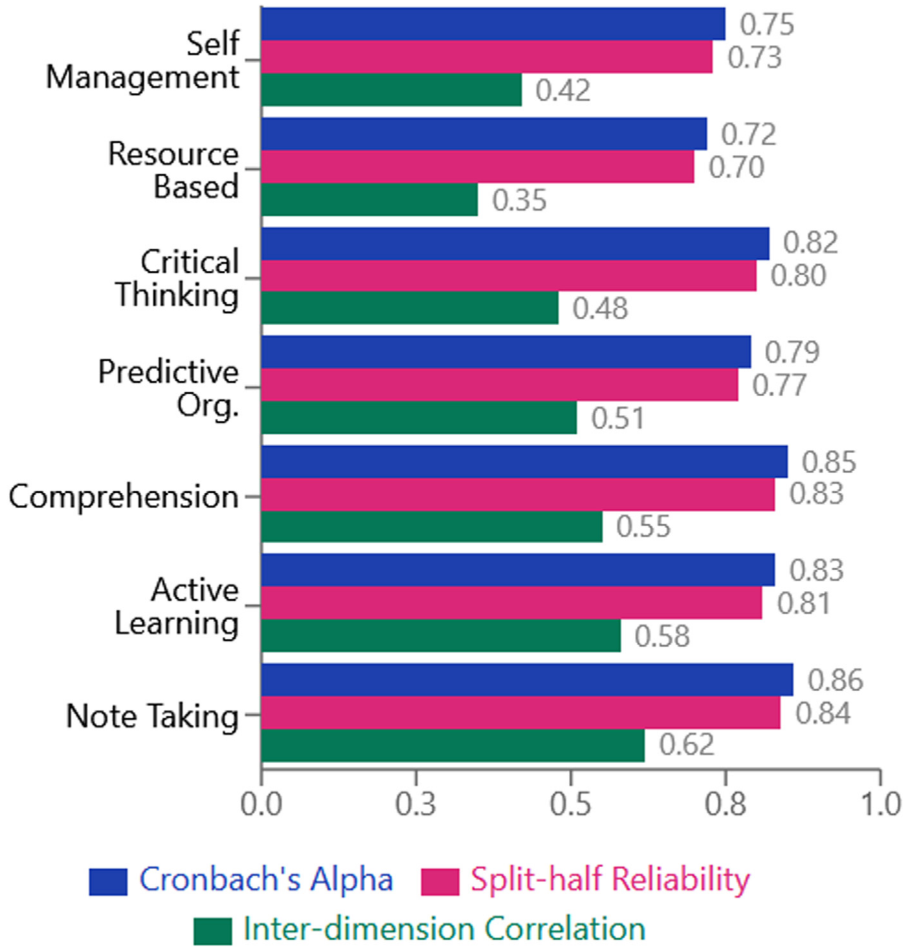

Fig. 1. Reliability coefficients, split-half reliability and inter-dimension correlations across all seven dimensions, along with key statistical validation results.

Interestingly, while critical thinking showed the highest overall adoption ($M = 3.64$, SD = 0.57), no significant gender differences were observed in this dimension ($p > .05$, $d = 0.003$), indicating that both male and female students employ critical thinking strategies at similar levels. This finding aligns with research by Wang and Degol [9], who suggested that while gender differences may exist in certain learning approaches, analytical thinking capabilities in STEM contexts often show more similarity across genders. Fig. 3 presents the gender comparison across strategy dimensions, visually highlighting the specific areas of convergence and divergence between male and female students.

Age-Related impact on strategy usage

Following the examination of gender-based differences, the analysis further explored whether age—another key demographic variable—might similarly influence strategy utilization patterns. The analysis of age-related effects on listening strategy utilization revealed significant variations across different age groups. Predictive organization showed a significant age effect (F(3226) = 3.216, $p = .024$, $\eta^2 = 0.041$), with 17-year-old students demonstrating the highest mean scores ($M = 3.69$, SD = 0.63, Mdn = 3.80, Q1 = 3.20, Q3 = 4.00). This effect size approaches the threshold between small and medium effects according to Cohen's [16] benchmarks and indicates that approximately 4.1 % of the variance in predictive organization strategy adoption can be attributed to age differences. In practical terms, this suggests that younger students tend to be more proactive in organizing and predicting lecture content, potentially reflecting their more recent structured learning experiences from secondary education.

Critical thinking abilities also showed significant age-related variation (F(3226) = 3.824, $p = .011$, $\eta^2 = 0.048$), with a progressive improvement pattern as age increased until age 19, followed by a decline in the 20+ age group. This effect size approaches Cohen's [16] benchmark for a medium effect ($\eta^2 = 0.06$) and indicates that approximately 4.8 % of the variance in critical thinking strategy adoption can be attributed to age differences. In practical terms, this suggests that developmental factors play a meaningful role in how engineering students apply analytical thinking to lecture content. The magnitude of this effect highlights the importance of

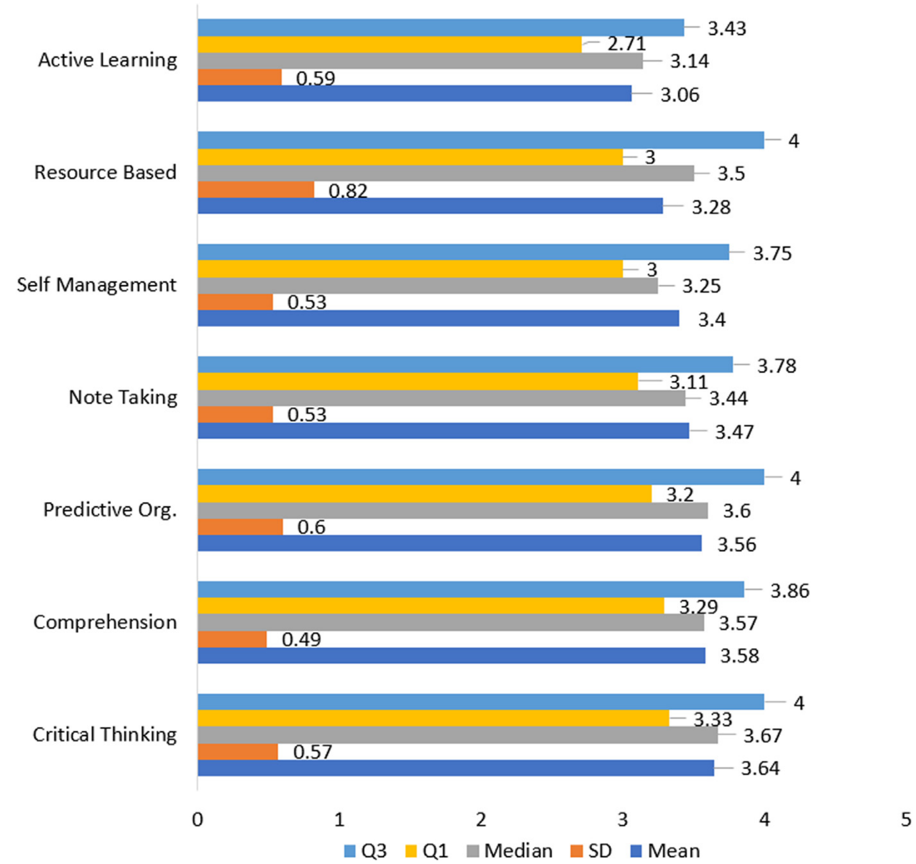

Fig. 2. Strategy adoption hierarchy.

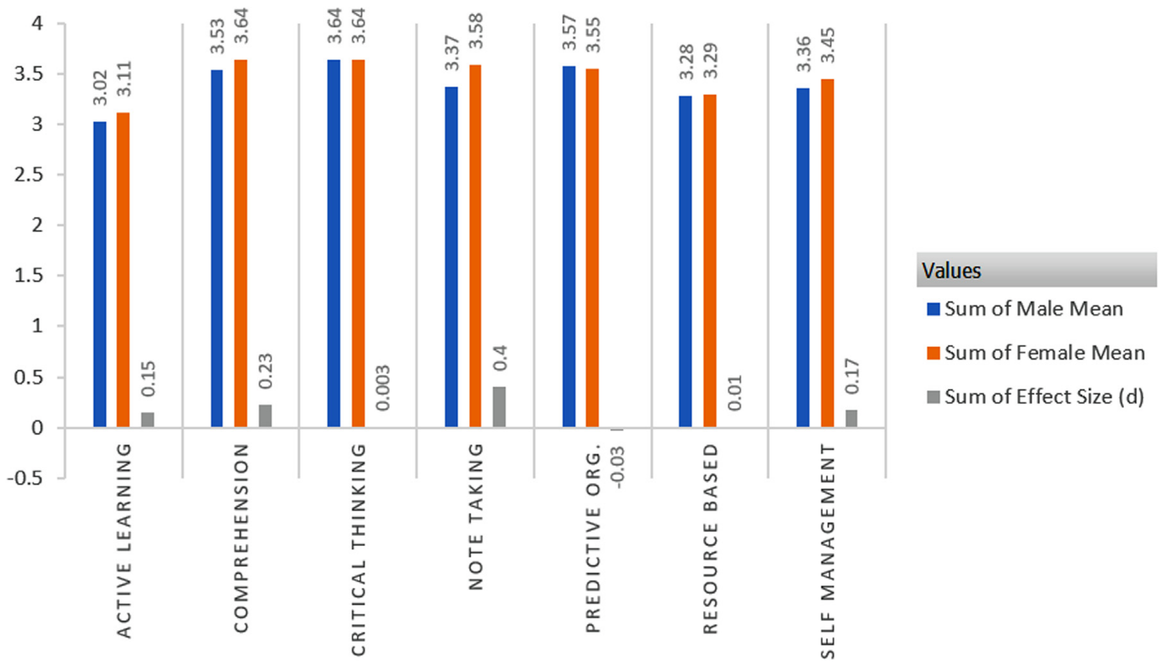

Fig. 3. Gender comparison across different strategy dimensions.

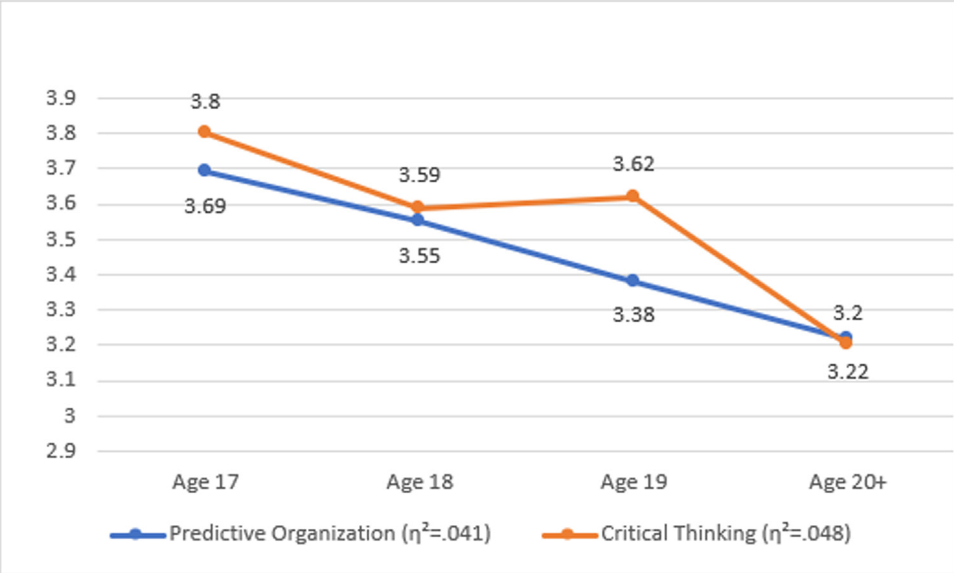

Fig. 4. Age-related trends in strategy usage.

age-appropriate scaffolding for critical thinking skill development in engineering education, particularly for younger students who may benefit from more structured guidance in analytical approaches to technical content.

The observed pattern of age-related differences aligns with metacognitive development theories proposed by Veenman and Spaans [10], who suggested that certain strategic thinking capabilities continue to develop throughout late adolescence and early adulthood. The effect sizes observed here, while modest in absolute terms, represent educationally meaningful differences that could inform age-differentiated instructional approaches in engineering education. Fig. 4 illustrates these age-related trends, visually representing the developmental patterns across different strategy dimensions.

When comparing the magnitude of demographic effects on strategy utilization, gender exerted a similar strength of influence on note-taking ($d = 0.40$) as age did on predictive organization ($\eta^2 = 0.041$, equivalent to approximately $d = 0.41$) and critical thinking ($\eta^2 = 0.048$, equivalent to approximately $d = 0.45$). These comparable effect sizes suggest that both gender and age represent similarly important demographic factors in understanding listening strategy patterns among engineering students, with neither substantially dominating the observed variance in strategy utilization.

Limitations and practical implications

The present study encountered the following methodological limitations that should be considered when interpreting the results. The primary limitation stems from sample characteristics, as data was collected from a single institution - Vellore Institute of Technology, Chennai. This institutional specificity may limit the generalizability of findings to other engineering colleges or educational contexts. Furthermore, the age distribution among participants was notably uneven, with a significant concentration in the 18-year age group (55.1 %) and relatively smaller representations in other age categories, particularly in the 20+ age group (3.9 %). The effect size magnitudes observed (ranging from $d = 0.40$ to $\eta^2 = 0.048$) should be interpreted with this sampling limitation in mind, as more balanced age representation might reveal different patterns of effects.

Statistical limitations also warrant consideration. The cross-sectional design of the study, while efficient for data collection, provides only a snapshot of listening strategies at a single point in time, limiting the researcher's understanding of how these strategies might evolve over students' academic careers. The reliance on self-reported data introduces potential reliability issues, as participants' responses may be influenced by social desirability bias or variations in self-awareness of their learning strategies. The modest effect sizes observed (particularly for age-related effects) suggest that additional factors beyond demographics likely play substantial roles in strategy utilization, pointing to the need for more comprehensive modeling in future research.

Despite these limitations, the findings offer important practical implications for engineering education. The observed gender difference in note-taking strategies ($d = 0.40$) suggests that educators should consider gender-responsive approaches to note-taking instruction. For instance, providing structured note-taking templates might particularly benefit male students, who demonstrated lower adoption of systematic note-taking approaches. The age-related effects on predictive organization ($\eta^2 = 0.041$) and critical thinking ($\eta^2 = 0.048$) highlight the importance of developmental considerations in strategy instruction, potentially warranting more scaffolded approaches for younger students and more autonomous approaches for older students.

Engineering educators could use these findings by implementing differentiated instructional approaches that acknowledge both gender and age-related variations in listening strategy utilization. Specifically, the following practical applications emerge from this research:

1. **Targeted Note-Taking Instruction**: Development of gender-responsive note-taking workshops that address the observed disparities ($d = 0.40$) between male and female students' approach to information recording.
2. **Age-Appropriate Strategy Scaffolding**: Creation of developmentally appropriate listening strategy supports that acknowledge the observed age-related differences in predictive organization ($\eta^2 = 0.041$) and critical thinking ($\eta^2 = 0.048$).
3. **Integrated Strategy Development**: Implementation of comprehensive listening strategy instruction that capitalizes on the strong inter-dimensional correlations observed between conceptually related strategies (r ranging from 0.55 to 0.62).

These practical applications are directly informed by the study's effect sizes, transforming statistical results into concrete teaching recommendations that recognize the meaningful impact of gender and age differences.

Ethics statements

Faculty permission was obtained to collect data from students during class time and all participants provided informed consent through Google Forms along with the questionnaire used for the study and the data was fully anonymized. The study has been submitted to the Institutional Review Board and is awaiting approval.

CRediT author statement

Bhuvaneshwari Palanisamy and Rajasekaran V contributed equally to formulating and enhancing the research problem. Bhuvaneshwari Palanisamy wrote the manuscript, structured, interpreted and validated the analysis. Rajasekaran V jointly supervised the work by Reviewing and Editing.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.mex.2025.103372.

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