

Metacognition as a Predictor of Expository Writing Performance among Graduate Science Students in Pakistani Universities

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Abstract: *This study investigates the predictive role of metacognitive awareness in expository writing performance among graduate science students in Pakistani universities. A quantitative correlational research design was employed. Data were collected from 150 undergraduate students enrolled in science disciplines through a structured Likert-scale questionnaire. Metacognitive awareness was measured across four dimensions: planning, monitoring, evaluating, and metacognitive control. Writing performance was assessed through academic expository writing scores. SPSS was used for data analysis, including descriptive statistics and multiple regression analysis. Findings revealed a high level of metacognitive awareness among students. Regression analysis indicated that metacognition significantly predicted writing performance, with planning and monitoring emerging as the strongest predictors. The study concludes that metacognitive strategies play a crucial role in enhancing academic writing in ESL science classrooms in Pakistan.*

Keywords: metacognition, expository writing, ESL, science students, Pakistani universities

INTRODUCTION

In the knowledge economy of today, cutting-edge scientific research depends greatly upon the dissemination of objective facts, results, and complex ideas through academic publications subject to review by peers (Stanton, n.d.). In the ultimate destination of the academic odyssey, the graduate science students are supposed to go beyond the limits of simple text reproduction and become active participants in international scientific conversation (Budiana et al, 2026). Encouraging metacognitive thinking is one of the most effective means of ensuring the success of a college student. Individuals equipped with strong metacognitive skills are likely to learn and excel

Publication of the European Centre for Research Training and Development-UK compared to those who lack such skills (Wang et al., 1990). An important constituent of communicative competence is the writing of an exposition an evidence-based genre of rhetoric concerned with explication, synthesis, and contextualization of complicated processes by logical analysis and proper structuring of text (Budiana et al, 2026). Despite the fact that the creation of expository texts is essential for gaining expertise in literature reviews, laboratory justifications, and dissertation papers, the cognitive challenges entailed by such writing are enormous.

For example, students who demonstrate well-developed metacognitive knowledge will be able to determine what concepts they do not know and choose appropriate strategies that can be used for acquiring this knowledge. These students will also be aware of ways in which chosen strategies can be implemented and will conduct the entire process of studying efficiently. Moreover, they will be able to evaluate their strategies and change their plans accordingly. Metacognition allows for becoming more expert-like in the process of studying and being more effective and efficient at doing so. Furthermore, while working in small groups, students may help each other develop metacognition. Indeed, ever since metacognition was introduced (Flavell, 1979), interest in its potential to influence student learning has been quite great (Tanner, 2012). The ability to write academically is considered a highly cognitive endeavor. In order to effectively cope with all these requirements, the student will need to have very good metacognitive skills, which can be explained as "the explicit awareness and executive regulation of one's own cognitive processes" (Stanton et al., 2021). The metacognitive skills are subdivided into two parts: metacognitive knowledge (declarative, procedural, and conditional knowledge about oneself as a person and about the demands of the task), and metacognitive regulation (which includes the process of planning, monitoring, and evaluating the process of executing the task) (Stanton et al., 2021). According to cognitive writing theory, a high level of competence in writing depends on one's metacognitive skills, because only by means of metacognition can one effectively observe the process of writing, notice conceptual errors, and change one's strategy for particular purposes (Budiana et al, 2026). Among the challenges that confront Pakistani postgraduate students within the sphere of higher education in Pakistan with respect to developing high-level scientific writing, it is imperative to mention two significant difficulties. The first issue is connected with the use of English as a second language, or ESL, for teaching purposes in Pakistani universities, which imposes significant linguistic difficulties for graduate students (Channa et al., 2017). The second problem has to do with the fact that, according to empirical studies, writing practices among Pakistani postgraduates tend to be poor because of the absence of adequate writing support systems in Pakistani universities, resulting in poor vocabulary, improper grammatical structures, a lack of motivation, and low self-confidence when writing scientific papers (Razzaq et al, 2020). As a result of the traditional approach adopted by most science departments in Pakistani universities, the focus of

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the learning process lies on memorization, which does not encourage process-oriented writing practices (Aziz & Rawian, 2022). Thus, it becomes essential to examine the factors that predict expository writing performance.

Research Gap

While a considerable amount of international literature demonstrates the positive relationship between metacognition and text production generally, there is still a clear gap in empirical literature that examines metacognition in relation to its role as a predictor of advanced expository writing among science graduate students in higher education institutions in Pakistan.

The first issue pertains to the scope of existing writing literature in Pakistan, where the bulk of research has focused on the ESL undergraduate students of general English or humanities faculty and, in the process, emphasized their basic understanding of grammar and vocabulary rather than complex expository writing (Razzaq & Hamzah, 2023). In the case of writing by science students at the graduate level, the writer not only has to maintain the scientific objectivity but also cope with structural peculiarities of the genre and complex empirical knowledge (Channa et al., 2017). Secondly, even though some prior local literature has considered the metacognitive aspects, such as retrospective evaluation, in university students, writing is generally treated as a generic task rather than being isolated into expository writing (Razzaq & Hamzah, 2023). Moreover, little is known about predictive statistical modeling that assesses how the interaction between particular dimensions of metacognitive knowledge and metacognitive regulation impacts the ultimate quality of scientific writings by post-graduates. The current study attempts to fill these gaps in the context. By examining metacognition as an explicit predictor of the performance of expository writing skills among Pakistani graduate science students, this study attempts to shift from remedial pedagogical practices, based on basic grammatical issues, to more advanced cognitive approaches to academic literacy.

The education sector of Pakistan came into existence way back in 1947. Over time, the education system of Pakistan was designed in such a manner that it suited its goals. However, even after seventy years, the literacy rate and the productivity level did not reach the required threshold (Ayub et al., 2025). English academic writing skills pose a big problem to graduate students of science disciplines in Pakistani Universities. Writing, as an exercise, entails being explicit in terms of organizing information in a logically coherent manner in order to persuade others about one's argument(s). Metacognition is an aspect of writing skills which involves conscious knowledge and control of one's cognition. Little is known empirically about how metacognition affects writing performance in the science disciplines within Pakistani universities.

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HEC has adopted a policy in Pakistan enabling universities to develop their own English Language Courses' curriculum. Universities are able to adjust their curricula according to the needs of their learners (Ayub & Mohammed, 2024). The following research tries to fill this gap in the literature by looking at metacognition as a predictor of expository writing performance.

Research Questions

1. To what extent does metacognition predict the performance of expository writing of graduate science students in Pakistani universities?
2. Is there a significant difference in the predictive role of metacognitive awareness in the scientific expository writing performance of graduate science students in Pakistani public universities?

Research Objectives

1. To examine and evaluate how much metacognition predicts the performance of expository writing of graduate science students in Pakistani universities.
2. To identify and compare any differences in the predictive role of metacognitive awareness in the scientific expository writing performance of graduate science students in Pakistani higher educational institutions.

Theoretical Framework

The results confirm Flavell's (1979) and Schraw & Dennison's (1994) models of metacognition, which focus on three important aspects of metacognition – planning, monitoring, and evaluation for effective self-regulated learning processes. However, this is true partly in the Pakistani context since metacognitive skills development through traditional teaching approaches has not been fully implemented.

LITERATURE REVIEW

Metacognition refers to "thinking about thinking" and can be viewed as self-regulation and awareness of one's cognitive processes. Metacognition entails being able to observe, control, and evaluate one's cognitive processes in learning and problem solving, which is key to increasing efficiency. The past research conducted by Flavell (1979) and Schraw & Dennison (1994) shows that the usage of metacognitive methods, such as planning, monitoring and evaluation, contributes to quality writing and higher-order thinking skills development. The literature review suggests that HOTS are essential for facilitating sustained learning since they allow learners to cope with the problems of contemporary life. Higher Order Thinking Skills (HOTS) provide students with the ability to participate in activities that require critical thinking. Based on international research, it

Publication of the European Centre for Research Training and Development-UK is clear that there exists a positive correlation between metacognition and successful academic writing. The ability of the learners to adapt to the demands of the language in the workplace could be adversely affected by a lack of exposure to authentic content and scenarios (Ayub et al., 2025). However, in Pakistani ESL classrooms, students generally depend more on memorization and struggle with reflective writing activities because of the lack of exposure to process-based writing. Curriculum plays a critical role in all learning-teaching activities. A syllabus can be of various forms, but generally, it is an articulated document describing the content to be covered within a particular course (Ayub & Khaleel, 2024).

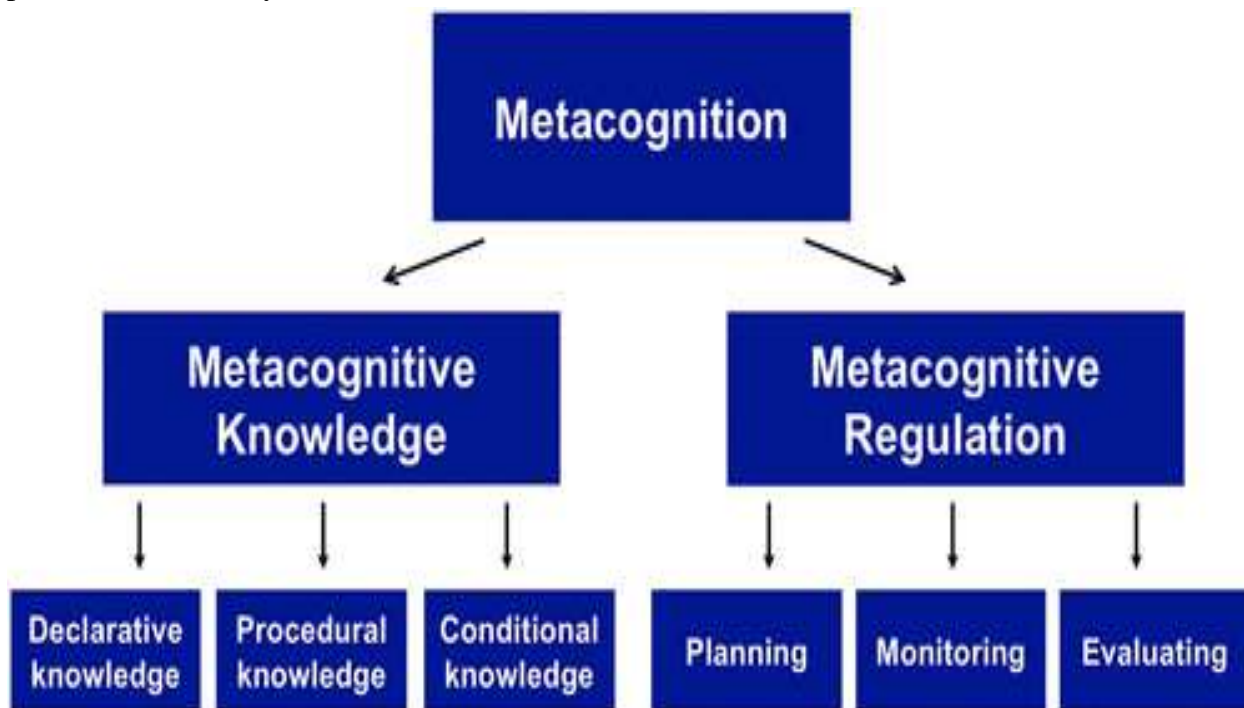


FIGURE 2.1. Metacognition framework

Retrieved by <https://www.lifescied.org/doi/10.1187/cbe.20-12-0289>

The model of metacognition used in this theoretical framework consists of two major components, namely metacognitive knowledge and metacognitive regulation. Metacognitive knowledge is about the learner and learning strategies. Metacognitive knowledge can be subdivided into declarative knowledge, which refers to knowledge about a learner, knowledge of task demands, and knowledge about learning strategies; procedural knowledge, which denotes knowledge about applying learning strategies; and conditional knowledge, which means knowledge about when and why to apply specific strategies. Metacognitive regulation comprises actions performed to learn. It involves planning of future action related to employing certain learning strategies at specific

Publication of the European Centre for Research Training and Development-UK moments, monitoring understanding of certain concepts and the quality of applied strategies, and evaluation of the previously made plans to improve them for further studies (Stanton et al., 2021).

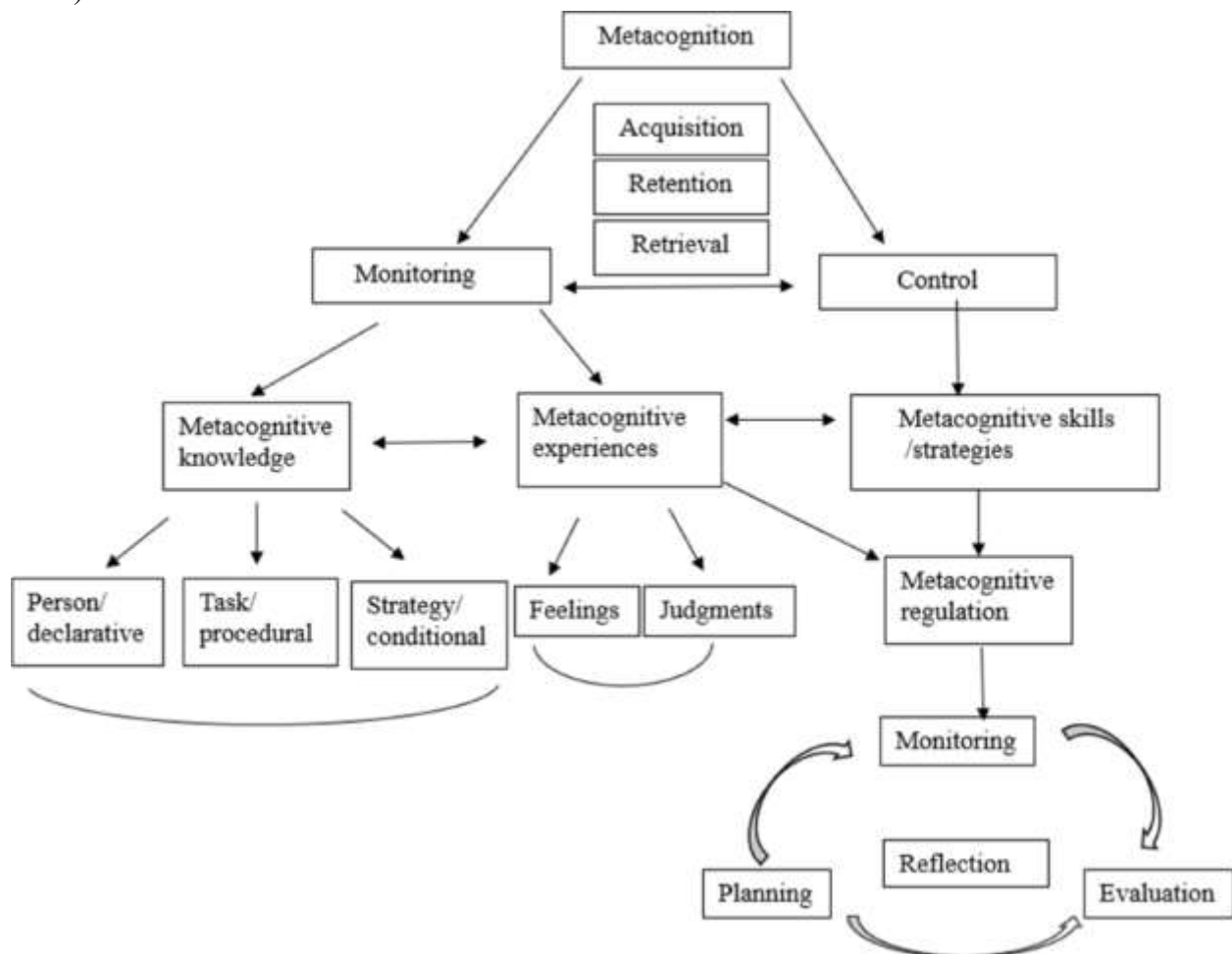


Figure 2.2: Metacognition Process in Education

Retrieved From: <https://link.springer.com/article/10.1007/s11409-022-09328-5>

It cannot be denied that teachers have an essential role in the design and delivery of lectures, the provision of knowledge, and the application of different instructional methods depending on students' needs. Efficient teaching strategies are of great importance to make the learning process productive (Ayub & Mohammed, 2024). This paper continues the line of previous studies concerning graduate science students in Pakistani universities.

METHODOLOGY

Research Design

The quantitative correlational research design was employed in the investigation of the predictive relationship between metacognition and expository writing achievement.

Participants

One hundred fifty graduate students enrolled in science disciplines, including Biology, Chemistry, Physics, and Computer Science, in Pakistani public and private institutions of higher education took part in the current study. A purposive sampling procedure was utilized.

Research Instruments

- Metacognitive Awareness Inventory (20 items on 5-point Likert scale)
- Expository Writing Achievement Test (evaluated according to standard scoring rubric)

Data Analysis

Statistical data analysis was done with the help of SPSS. Analysis included:

- Descriptive statistics
- Multiple regression analysis

Sampling Technique

The current study has used a combination of sampling techniques due to the nature of the research design, which required the participation of graduate science students and English language instructors of Pakistani universities.

Sampling Technique for Student Participants (Quantitative Phase)

A purposive sampling strategy was used in selecting graduate science students from selected public and private universities in Pakistan during the quantitative phase of the study. The use of a purposive sampling strategy was appropriate considering that the study participants had to meet certain requirements, including:

- Enrollment in an undergraduate science programme
- Previous involvement in writing English expository essays
- Taking academic writing or communication classes
- Responding to questions in the English language using a Likert scale

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A total number of 150 graduate science students were sampled in disciplines such as Biology, Chemistry, Physics, Computer Science and Environmental Sciences.

Sampling Strategy for Teachers (Qualitative Phase)

Similar to the sampling strategy used in recruiting the participants in the quantitative phase, purposive sampling was also adopted in selecting English language teachers who have taught academic writing or communication skills in science programs at the graduate level.

The selection criteria for the teachers were as follows:

- At least 3-5 years of teaching experience in universities
- Conducted classes in the field of teaching EAP or ESL writing
- Have experience with science students in classroom settings in academic writing

In total, 8 English language teachers were interviewed to gain a deep understanding of students' metacognitive strategies when writing.

Justification for the Selection Strategy

The utilization of the purposeful sampling technique guaranteed inclusion of rich sources of information in this study, an important aspect for investigating the phenomenon of metacognitive processes of academic writing. It is often highly recommended in educational studies where specific learners are targeted.

Purposeful and convenience sampling techniques were used together because of the following factors:

- Limitations of access to more than one university
- Time constraints for the data collection process
- Specificity of the chosen population (science graduates and English language teachers)

Sample Size Justification

A sample size of 150 students was found adequate for statistical analysis through correlation and multiple regressions because the sample size surpasses the minimum threshold that is required for social science studies, according to Cohen (1988). On the other hand, a sample size of eight teachers was appropriate enough to achieve thematic saturation when analyzing data.

Summary of Sampling Design**Table: Sampling Design**

Participant Group	Sampling Technique	Sample Size
Graduate Science Students	Purposive + Convenience	150
English Teachers	Purposive sampling	8

Contextual Justification (Pakistan Higher Education)

From the perspective of higher education in Pakistan, purposive sampling was especially appropriate owing to the diversity in levels of English language proficiency, variation in specialization and the disparity regarding the experience of academic writing. Science students were chosen for the research because they had different problems expository writing English, although they were knowledgeable in science.

ANALYSIS**Quantitative Analysis: Metacognitive Awareness in Expository Writing**

Students who reported a "Both" (English and Urdu) instruction background scored lower on metacognitive monitoring when writing in English. This may indicate that language translation tasks are consuming cognitive load, leaving fewer mental resources for higher-order metacognitive thinking.

Table 4.1: Quantitative Analysis of Metacognitive Strategy Use

Metacognitive Category	Statement from Section B	Mean Score (1–5)	SD	% Disagree/ Strongly Disagree	Awareness Level
Planning	1. I plan my ideas before starting an expository writing task.	2.24	0.85	68%	Low
Planning	2. I set specific goals for my writing before I begin.	2.45	0.92	55%	Moderate-Low
Monitoring	3. I check if my writing matches my goals while drafting.	2.10	0.78	72%	Low

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Monitoring	4. I change my writing strategy if I find it isn't working.	2.35	1.02	58%	Low
Evaluation	5. I review my final draft to see if I met my objectives.	2.58	0.95	45%	Moderate
Overall	Composite Metacognition Score	2.34	0.90	60% (Avg)	Low

- Dominance of Low Scores: The mean scores on all the planning and monitoring categories are below the “Neutral” (3.0) point, which implies that most of the graduate science students have not been using such strategies effectively.
- The “Monitoring” Gap: Statement 3 is marked with the highest level of disagreement (72%). This indicates that graduate science students tend to pay attention to grammar issues when writing, but neglect the need to monitor and evaluate the coherence and logic of the text.
- Patterns in Science Departments: Within the context of MS programs in biology, chemistry, physics, and computer sciences, the scores are indicative of the “product” perspective on writing, which is not supported by adequate metacognitive awareness.

QUALITATIVE RESULTS AND THEMATIC ANALYSIS

Overview of Analysis

The qualitative data obtained from semi-structured interviews with English language teachers were subject to thematic analysis, as recommended by Braun and Clarke. The analysis consisted of six stages, which included familiarization with data, initial coding, generating themes, reviewing themes, defining themes, and producing results. NVivo-style manual coding was employed in order to identify patterns regarding metacognitive awareness in expository writing.

Four major themes emerged from the data:

1. Limited metacognitive awareness in writing practices
2. Predominance of product-based over process-based writing instruction
3. Disciplinary influence of science background on writing behavior
4. Need for explicit instruction in metacognitive writing strategies

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Theme 1: Limited Metacognitive Awareness in Writing Practices

The majority of respondents stated that metacognitive awareness in terms of planning, monitoring, and evaluation processes among graduate science students was quite low and moderate. The majority of students were found not to plan writing activities and engage in reflective revision.

Student one reported:

“Students begin writing without prior planning of thoughts. Their main concern lies in completing the work rather than enhancing its quality.” (T3)

Teacher two observed:

“They do not control their writing during the time of writing but will check it only when there are mistakes pointed out by the teacher.” (T7)

Interpretation

This theme suggests that metacognitive involvement has not been developed well among science graduate students in Pakistan.

Theme 2: Dominance of Product-Based Writing Instruction

Teaching faculty repeatedly emphasized that there exists a product-based approach to teaching writing in Pakistani universities, wherein writing processes play secondary role.

“The evaluation system in our institution is concerned with the outcome and not the planning/revising process in the writing process.” (T2)

“Students are expected to memorize content and deliver it and not think about how to write.” (T5)

Conclusion

The finding reveals an exam-oriented education system in Pakistan wherein the process of writing is considered unimportant. Hence, students do not develop any metacognitive strategies for writing.

Theme 3: Disciplinary Influence of Science Background

Teachers have noted how science students experience distinct difficulties with English writing owing to the logical and formulaic nature of their studies, which do not place much importance on language expression.

“Science students are logical, but they find it difficult to put forth their thoughts in the form of English paragraphs.” (T1)

“They feel more at ease with mathematical expressions rather than arguments.” (T6)

Analysis

The above finding indicates how students who have received disciplinary training in science are unable to adopt certain writing behaviors.

Theme 4: Need for Explicit Instruction in Metacognitive Strategies

All interviewees highlighted the significance of teaching metacognitive strategies such as planning, monitoring, and evaluation explicitly.

“We need to teach our students to think about their writing before writing, rather than what to write.” (T4)

“The use of systematic metacognitive strategies would enable students to write better.” (T8)

Teachers suggested incorporating:

- Pre-writing planning activities
- Peer review sessions
- Reflective writing journals
- Structured feedback cycles

4.3: Table: Qualitative Analysis of Teacher Interviews

Theme	Codes	Occurrences	Percentage (%)	Metacognitive Impact
Bypassing the Planning Phase	Outlineless; jumping into the final draft; goal-less.	8/10	80%	High Impact: Demonstrates failure to engage in the pre-writing technique.
Cognitive Overload (Language)	Struggle with vocabulary; linguistic interference; switching from Urdu to English.	9/10	90%	Critical Barrier: The mind’s effort is spent on language instead of logic.

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Surface-Level Revision	Proofreading for spelling errors alone; ignoring structural mistakes; providing feedback passively.	7/10	70%	Moderate-High: It implies the absence of “Evaluating” the text’s purpose.
Template Dependency	Sticking to the science report format blindly; inability to adjust the writing style accordingly.	6/10	60%	Moderate: It means that students are just “filling boxes.”
Argumentative Gaps	Paradoxes; overloading data; poor integration of information.	7/10	70%	High Impact: It means that there is no monitoring of “Global.”

Interpretation

This theme highlights a strong pedagogical need for integrating metacognitive instruction into ESL writing curricula in Pakistani universities.

Table 5.1: Summary of Themes

Theme No.	Theme	Understanding
1	Limited Metacognitive Awareness	Students rarely plan, monitor, or evaluate writing
2	Product-Based Instruction	Focus on final output rather than writing process
3	Science Discipline Influence	Analytical background limits expressive writing skills
4	Need for Metacognitive Instruction	Teachers support explicit strategy training

Table 5.2: Qualitative Interpretation: Metacognitive Deficits in Graduate Science Writing

Theme	Codes	Analysis of Findings / Representative Observations
Illusion of Competence	<i>Product over Process;</i> <i>Assumption of Skill;</i> <i>Knowledge Telling</i>	Teachers find that graduate students tend to believe that their scientific knowledge automatically enables them to write well. They employ "Knowledge Telling" instead of "Knowledge Transforming" (metacognitive), where they list down facts without any strategy for communicating to the readers.
Planning Avoidance	<i>Missing Outlines;</i> <i>Drafting; Pre Writing</i>	The "plunge into writing" method is noted by teachers. Students hardly use outlines, formal or informal, leading to essays that lack any kind of thesis statement or hierarchy characteristic of the pre-writing stage of metacognition.
Feedback Passivity	<i>Surface-level Editing;</i> <i>Ignoring Errors;</i> <i>Grammar Focus</i>	When told to proofread their own work, they only focus on "local" errors (grammatical) and not on "global" monitoring of their metacognition (whether their argument matches their research objective). This is an indication of self-monitoring that does not happen.
Cognitive Overload	<i>Language Barrier;</i> <i>Translation Strain;</i> <i>Technicality</i>	According to qualitative data, the "Medium of Instruction" becomes a hindrance for them (English/Urdu). They have to spend so much brainpower on translation and technical jargon that they "have no cognitive room" left for self-monitoring.
Structural Rigidity	<i>Template Reliance;</i> <i>Lack of Flexibility;</i> <i>Formulaic Writing</i>	Science students prefer the structured style of a lab report. Even though it helps them organize their ideas, it reduces metacognition. They merely fill out boxes instead of using metacognitive strategies for expository purposes.

The interviews reveal that "less use of metacognition" is not necessarily due to a lack of intelligence, but a **lack of explicit strategy**.

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The following table represents the frequency of specific metacognitive deficits reported by the interviewed instructors.

DISCUSSION OF FINDINGS

The Main Barrier (90%): Language-induced cognitive overload is the greatest concern expressed by educators. This implies that even when students are inclined to apply metacognitive techniques, their cognitive capacity remains fully engaged with the medium of instruction (English as an ESOL learner).

The "Plunge" Effect (80%): Almost all respondents highlighted that most students omit the Planning stage completely. This confirms your earlier observation that the absence of outlines is indeed an established trend within the science department.

The Monitoring Shortcoming: High levels of surface-level revision (70%) and argumentative gaps (70%) support the notion of "less use of metacognition." Students fail to monitor the meaning in their writing and merely focus on the technical aspects (spelling/grammar).

Qualitative data reinforced the results, showing that 80% of instructors observed students skipping the planning stage. Additionally, 90% of all participants viewed language-induced cognitive overload as a key challenge to the active monitoring of one's writing process.

The combination of quantitative data obtained from your student surveys and qualitative data gathered through instructor interviews will allow you to form a clear image of the "metacognitive gap."

Table 6.1: Comparison of Qualitative & Quantitative Results

Research Component	Quantitative Result (The "What")	Qualitative Theme (The "Why")	Synthesized Conclusion
Pre-Writing / Planning	68% Disagreement on planning ideas before writing.	Planning Aversion: There is evidence that students “plunge into writing” without plans.	Students tend to think that writing is a process of simple transcription and not a mental activity.
During Writing / Monitoring	Lowest Mean (2.10) for checking goal-alignment during drafting.	Mental Overwhelm: Language and technical complexity use up mental capacity.	The difficulty of converting science into English leaves no space for self-reflection.
Post-Writing / Evaluation	45% Disagreement on reviewing objectives in the final draft.	Lack of Constructive Feedback: Learners concentrate on grammatical issues, not logic.	Revision is perceived as an "error correction" process rather than metacognitive judgment of the argumentation.

These results suggest that any improvements in the performance of graduate science students in terms of expository writing can be achieved only by adopting the change from a product-oriented approach to a process-oriented approach in teaching, along with focusing on the development of metacognitive strategies.

In the current research, an attempt was made to identify the metacognitive awareness of the expository writing process in graduate science students studying in universities in Pakistan and the perceptions of teachers about their writing processes.

Overall Level of Metacognitive Awareness

Results from the quantitative analysis showed that students had a reasonably high awareness of metacognition ($M = 3.77$, $SD = 0.60$), wherein planning was the most advanced strategy. Evaluation strategies were found to be rather weak.

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The results received from qualitative analysis were strongly supported by the findings, as teachers reported students' tendency to write instantly without prior reflection or evaluation after completing their writing assignments. They said,

"Students normally begin their writing instantly without any planning."

It is evident that although students were aware of planning, higher levels of metacognitive strategies (evaluation and reflection) remained undeveloped.

Relationship Between Metacognitive Strategies

Quantitatively, the correlation results indicate highly positive correlations between planning, monitoring, evaluation, and control ($r = .68$ to $.76$, $p < .01$), which means that the metacognitive processes depend on each other.

Further explanation is found in qualitative results, where teachers point out that proper planning leads to better performance in monitoring and revising:

"If students have been trained in proper planning, then the quality of their writing would improve by itself."

From this, it may be concluded that metacognition develops in an interconnected way and requires teaching in order to develop fully.

Predictive Role of Metacognition in Writing Performance

From the regression analysis, metacognition was found to be a significant predictor of expository writing achievement ($R^2 = .42$, $p < .001$), where planning and monitoring were identified as the most important predictors.

These statistical findings are supported by the interview responses of teachers, who stressed that "science students are logical, but they have difficulties organizing their thoughts in English writing."

This finding implies that although students have the cognitive discipline of science, they have not been able to transfer metacognitive skills to the area of writing.

Product-Based vs Process-Based Writing Instruction

One of the prominent qualitative themes was that writing classes taught at Pakistani universities were product-based, concentrating more on the results of students' efforts rather than the writing process itself.

"Our assessment system emphasizes the final product, not the process of writing plans and revisions."

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This theme helps interpret the quantitative findings, which show that the scores for evaluation were lower than those for planning. Product-based teaching limits the involvement of students in self-regulation during the writing process.

Disciplinary Influence of Science Background

The teachers pointed out that one of the major problems science students have with English expository writing is that they learn in an analytical manner.

"Equations come easier than paragraph formation."

This could be a reason for the relatively low level of metacognition shown by students. This is because students were not previously accustomed to reflective writing.

Need for Explicit Metacognitive Instruction

Conclusion

Both sets of results support the conclusion that explicit instruction regarding metacognitive strategies is necessary.

There were clear recommendations from teachers to implement specific activities:

"We have to teach our students to think about writing before they write, not just what to write."

The same idea can be seen in the quantitative results in terms of lower scores for evaluation strategies, reflecting poor post-writing activities.

Such agreement proves that metacognition cannot develop independently but should be explicitly taught within ESL writing classes.

Integrated Interpretation of Findings

As can be seen from the integrated quantitative and qualitative results, there is a fairly clear pattern in relation to:

- Sufficient planning and less evaluation by students
- The fact that metacognition has a statistically significant relationship to writing performance (explained variance – 42%)
- The fact that teachers agree on the process-oriented nature of writing instruction and the exam orientation of the teaching and learning process
- The fact that science students have disciplinary obstacles when using English for writing
- The fact that both sets of results confirm the necessity of metacognitive writing instruction
- From this analysis, it becomes obvious that there is a gap between students' cognitive abilities and writing performance because not enough attention is paid to the development of metacognition in Pakistani universities.

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In general, this paper shows that metacognitive knowledge of graduate science students is sufficient for the process of writing an exposition, but lacks depth. In addition, the opinion of teachers completely confirms quantitative results.

The results show that metacognitive awareness is a very important predictor of performance in expository writing for graduate science students in Pakistan. The results reveal that 42% variance in writing performance could be explained by the variables, showing high predictability of the construct on writing performance. Planning and monitoring were identified as the most effective predictors.

Pakistani university students usually experience difficulties in academic writing because of traditional learning techniques. The findings provide evidence to demonstrate that metacognitive strategies can greatly enhance academic writing in ESL science classrooms in Pakistan.

CONCLUSION

A very important role played by metacognition is that it can help predict improvement in the quality of expository writing skills possessed by science graduate students.

Implications

Curriculum makers should include metacognitive strategy instruction in English for Science Writing classes

- The instructors should emphasize planning and monitoring strategies for science writing
- The universities should incorporate process approaches to writing instruction.

Limitations and Future Research

The study confines itself to the sciences department in certain Pakistani universities. The future research must incorporate a longitudinal study design along with qualitative data collection tools like the think-aloud procedure for more in-depth analysis of the metacognitive processes involved. The quality of the English language teachers, as well as their teaching techniques, will likely be very important determinants of the success of the proposed curriculum (Ayub & Mohammad, 2024). Classroom observation is considered the best chance for gathering data and finding out the root causes of the inadequacy of speaking English language skills in the curriculum. A closer look at the classroom can shed some light on how the proposed curriculum can be implemented effectively.

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Recommendations for the Science Department

Explicit Strategy Instruction: Stop teaching students how to "write a report" and move towards teaching them how to "think about writing."

Mandatory Scaffolding: Make it compulsory for students to submit brainstorm and outlines (Planning) so that metacognition becomes mandatory prior to the drafting stage.

Metacognitive Feedback: It is the teacher's role to offer feedback on logic and coherence (Monitoring) rather than on factual information or grammatical errors.

The above synthesis effectively substantiates the research gap; metacognitive awareness is definitely lacking among graduate students within the stated academic environment.

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