JOURNAL OF LANGUAGE, IDENTITY & EDUCATION
https://doi.org/10.1080/15348458.2024.2338364

Routledge
Taylor & Francis Group

Adolescent English Learners' Awareness of Disciplinary Writing and Academic Language in Science Classrooms: The Affordances of a Register-Functional Perspective

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ABSTRACT

This article reports findings from a study that investigated English learners' (ELs') developing awareness of disciplinary writing and academic language in science courses in a U.S.-based high school. Based on an analysis of writing samples, this case study first introduces the situational and linguistic characteristics of two science writing tasks in forensics and oceanography. The author then explores ELs' developing understanding of science writing and academic science language via ethnographically oriented interviews. Informed by the Register-Functional perspective and Academic Literacies frameworks, the analyses demonstrate higher EL sensitivity to vocabulary, but not grammatical structures yet. Writing practices in science classes shape ELs' understanding of disciplinary writing in unexpected directions. The situational analysis of writing and ELs' perspectives provide a systematic approach for understanding learner needs in writing and integrating language into content instruction. Implications for EL education in science and teacher collaborations are provided.

KEYWORDS

Academic language; disciplinary writing; language awareness; science writing; situational analysis; written science register

Introduction

In the past decade, rigorous educational standards and increased numbers of English learners (ELs) in the U.S. public schools have made writing instruction a significant element of content areas (Kibler et al., 2016). The U.S. public school system has experienced notable shifts in their educational standards with the implementation of the Common Core State Standards (National Governors Association, CCSS, 2010) and the Next Generation Science Standards (NGSS Leads States, 2013). Developed by literacy and content area experts to provide uniform and high-quality standards across the United States, these educational standards promoted the focus of instruction on disciplinary literacy practices and communicative demands such as writing in the content areas, comprehending complex texts, and using academic and specialized language (Kibler et al., 2016; Shanahan & Shanahan, 2017).

While the U.S. educational landscape witnessed such academic expectations through rigorous standards, classroom demographics have also changed considerably with the number of ELs steadily growing from 9.2% in 2010 (or 4.5 million students) to 10.4% in 2019 (or 5.1 million students) according to the statistics from the U.S. Department of Education (National Center for Education Statistics, 2021). Many ELs arrive in the U.S. secondary school contexts with limited formal education, which puts them behind their peers in terms of academic achievements and English language proficiency (Enright, 2010; Furlong, 2022). Therefore, deliberate efforts to understand ELs' writing and language needs will contribute to their academic development and preparation for postsecondary

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educational contexts. In this article, I investigate ELs' discourses on disciplinary writing as well as science language use to provide a deeper understanding of their language awareness.

Background

Educational standards in U.S. public schools task teachers with building disciplinary literacies, which refer to "specialized literacy practices of a disciplinary domain" (Moje, 2008, p. 256). Disciplinary literacy in science requires building learners' knowledge of science content well as their specialized literacy and language skills that the scientific community possesses and uses in communications (Fang & Coatoam, 2013; Moje, 2015; Norris & Phillips, 2002, 2003; Shanahan & Shanahan, 2008). Some of the disciplinary practices articulated in the NGSS and states' own science standards include science and engineering practices that incorporate writing such as explaining scientific investigations, building scientific arguments using evidence, writing in different scientific genres, and interpreting scientific language (Akkus et al., 2007; Drew et al., 2017; NCTA, n.d.; Norris & Phillips, 2002, 2003; Shanahan & Shanahan, 2008).

Research on promising practices of supporting ELs in K-12 STEM subjects has shown that ELs generally have limited opportunities in science classrooms to engage in rigorous disciplinary literacy practices (e.g., supporting claims) and activities that include writing with different genres (National Academies of Science, 2018). The research committee conducting the consensus report suggested that ELs engage in multiple modalities (e.g., interactions, writing) to use language functionally (National Academies of Science, 2018). Language and literacy scholars also reported that providing ELs with access to the language of informational writing plays a particular role in enhancing their literacy and language awareness in science (Palincsar & Schleppegrell, 2014). Palincsar and Schleppegrell trained upper elementary teachers on integrating metacognitive awareness discussions on how writers signal likelihood in science writing. Subsequently, teachers engaged learners in collaborative discussions and tasks to identify language associated with the degrees of likelihood in informational texts, which raised learners' awareness of metalanguage to support their writing. By understanding the language used in the disciplines and dissecting the scientific vocabulary and common linguistic structures, ELs can comprehend the scientific texts better and mimic such language forms in their writing more independently (Moje, 2008; Palincsar & Schleppegrell, 2014).

Research on supporting ELs in science classrooms has predominantly focused on the integration of language and content instruction as a pedagogical approach in relation to the challenges associated with advanced literacy demands (Lyon & Tolbert, 2022). While there is a growing body of research on unpacking the linguistic demands of written texts as systemic functional approach (de Oliveira et al., 2021; Palincsar & Schleppegrell, 2014), a conspicuous gap exists pertaining to ELs' perspectives on science writing and language use to inform such pedagogical efforts. There is a growing need for approaches to integrate adolescent writers in the processes of exploring ELs' needs in content classrooms by specifically focusing on writing as a social and linguistic practice. This research aims to address the existing gap by adopting a disciplinary and sociolinguistic approach to scrutinize ELs' experiences and discourses related to science writing. The goal is to provide practitioners and teacher educators with tools to make sense of writers' growing awareness of disciplinary practices and develop support based on the social and linguistic context of writing.

Theoretical framework

This study uses Academic Literacies as a theoretical framework, which is concerned with "the complexities of academic communication," particularly writing in K-12 and higher education settings to address the issues related to developing writers' language use (Lea & Street, 2006; Lillis & Scott, 2007, p. 6). This framework is particularly relevant to the study of adolescent literacy since ELs develop their academic literacies in different disciplines by engaging in the disciplinary practices such as writing in different genres. Academic literacies perspective

considers writing a social activity that is shaped within the practices of the disciplinary communities. ELs must switch from everyday conversational language to academic language within and across disciplines (Gibbons, 2009; Lea & Street, 2006; Lillis & Scott, 2007). In science classrooms, for instance, ELs are apprenticed into different forms of writing and are supposed to integrate the language patterns associated with science content (e.g., noun phrases, complex clauses) with a heightened awareness (de Oliveira et al., 2021; Fang, 2006; Gee, 2006; Lemke, 1990). Since this cycle repeats in other disciplines as well, ELs need to utilize their developing academic language repertoires carefully to engage in the specialized science writing practices (Moje, 2015).

This study also utilizes the Register-Functional Framework (Biber & Conrad, 2019; Biber et al., 2011; Biber et al., 2022) to specifically analyze the situational contexts of two science writing tasks as well as examine ELs' developing understanding of writing and language use. Biber and his colleagues compiled a corpus of scientific texts to understand the pervasive linguistic features of scientific language. Based on their analyses, they proposed a developmental model of grammatical complexity (Biber & Gray, 2016; Biber et al., 2011). Based on this Register-Functional framework, developing writers are suggested to depart from clausal structures and use more noun phrases, nouns, and nominalizations for precision and information-packaging purposes (further explanation below). This framework helped me explain the characteristics and the linguistic demands of science writing tasks, and thus contextualized the demands of writing and EL use of academic language in science tasks. While the Academic Literacies framework theoretically situates writing as a social practice within disciplines, the Register-Functional framework specifically assists in describing the situations of writing and language use. Both frameworks complement each other to better explain the challenges associated with developing writing in science.

Using a sociolinguistic approach to language variation, the register-functional perspective defines academic language (or academic prose) as a broad register, which is "a language variety associated with both a particular situation of use and with pervasive linguistic features that serve important functions within that situation of use" (Biber & Conrad, 2019, p. 31). In other words, the academic writing genres employ lexical and grammatical structures due to the situational contexts of writing tasks (Staples & JoEtta, 2022). In their situational and linguistic analysis of first-year writing and engineering writing tasks, Staples and JoEtta found that design reports and research reports written in two different college courses showed similar use of language features (e.g., noun phrases, certainty and likelihood verbs) due to their similar communicative purposes. However, the design report task included more first-person pronouns (I, we) since the writers were previously provided with a sample report that included such structures in the course. The situational contexts that influence the use of specific lexical and grammatical structures as in these examples include different modes (e.g., written, spoken), content, participant relationships (National Academies of Sciences, 2018) as well as communicative purposes, settings, and the circumstances of writing (Biber & Conrad, 2019). According to Biber and Conrad, more specific registers within academic writing also exist such as lab reports in science, summaries in social studies, and argumentative writing in language arts that may be situationally and linguistically different from each other. In this study, the written academic language variety used in science writing tasks will be broadly referred to as the *register of academic science writing* (Biber & Gray, 2022a).

Research on academic registers has elaborated on the functional use of linguistic features in scientific writing (Biber & Clarke, 2002; Biber et al., 2011; Biber et al., 2021). For example, Biber et al.'s (2011) developmental model based on corpora of advanced academic texts suggested the favored use of noun phrasal structures in academic registers which package information and express precise and abstract ideas (e.g., nouns with a pre-modifier as in ***considerable*** *growth*, nouns with a post-modifier as in *the warming* ***in the arctic***). Studies on historical scientific texts also found a rise in the use of noun phrasal structures, nominalized verb forms (e.g., grow - **growth**), and converted nouns (e.g., **decline** as a noun) in the last century to express complex knowledge in academic science writing (Biber & Gray, 2022b; Biber et al., 2022). Conducted primarily in tertiary and professional writing

settings, further studies found that noun-phrasal structures correlate with English L1 and L2 writers' proficiency or writing scores (Parkinson & Musgrave, 2014; Staples & Reppen, 2016; Staples et al., 2018).

While studies conducted in secondary settings are relatively scarce, existing scholarship on the register of secondary school subjects also demonstrated the frequent use of noun phrases and nominalizations (Durrant & Brenchley, 2019; Durrant et al., 2021; Green, 2019; Reppen, 1994). For example, in Green's study, science subjects such as biology and chemistry were found to heavily incorporate noun phrasal structures. These linguistic features and their functions are relevant to science writing in schools since the NGSS state standards generally expect writers to provide information in precise language (NGSS Lead States, 2013). The complex nature of language required in secondary school subjects (Green, 2019; Rainey et al., 2018; Shanahan & Shanahan, 2017) requires adolescent ELs writers to demonstrate an understanding of such language forms and embed them deliberately to communicate complex meanings (Drew et al., 2017; Scardamalia & Bereiter, 2010).

Language and literacy research has widely studied the language and literacy demands in science and other subject areas. However, impacted by the classroom instruction and writing practices, secondary ELs' perspectives on academic science writing and language have received much less attention. Furthermore, studies involving a linguistic analysis of secondary EL writing with a register approach are limited compared to those in post-secondary contexts (e.g., Larsson & Kaatari, 2020; Staples & Reppen, 2016). Combined with verbal accounts of science writing experiences, linguistic analyses may provide a broader picture of ELs' academic language awareness and provide insights for practitioners and teacher educators. Additionally, using ELs' experiences in writing and language development to inform instructional and curricular development is a linguistically and culturally responsive practice (Muñiz, 2019). A study like mine is also suitable for building EL teachers' knowledge of disciplinary writing and creating opportunities for collaboration between teachers for writing support. Therefore, this study aimed to explore the following research questions:

1. What are the situational and linguistic characteristics of the science writing tasks that ELs accomplished during the school year?
2. How does ELs' understanding of the register of academic science writing emerge in their discussions of instructional practices in science and writing experiences?

Methodology and data analysis

This exploratory case study draws on data on disciplinary writing practices and ELs' writing experiences that was collected in a large urban U.S. high school science program in Arizona between January-May in 2021 (Yaylali, 2022). At the time of this research, 82% of the student population at Southwestern high school consisted of students of color, including 95 ELs (8% of the total population). The high school was chosen because of its location in a refugee settlement neighborhood and its high number of refugee-background ELs primarily coming from Latin American and African countries.

The design of the current research involves a description of social and disciplinary contexts of science writing (Barton, 2012; Wortham, 2008) as well as a discussion of language use in authentic texts and learner writing samples (Biber, 1994; Biber & Conrad, 2019). At the time of the research, the science program had an increasing number of ELs with various English proficiencies. Due to the recent changes in Arizona State's language policies, ELs were allowed to take content area courses without having to pass any English proficiency exam to take college credits. However, this shift also created tension within the program since the science teachers (as well as others) were tasked with more accountability and language and literacy support. With the approval from the University of Arizona's institutional review board and participant consents, this study utilized learner writing samples from conclusion analysis letters and summaries ($N = 79$), authentic science articles ($N = 11$) as well as interview data from eight ELs who completed the writing assignments in oceanography and forensic science courses, both of which had the highest concentration of ELs within the science program. About

Table 1. Participant demographics (All pseudonyms).

Participants	Exited the ESL Program	Grade	Country	Years in the United States
Rana	No	9	Uganda	6
Hanife	No	11	Iran	2
Maira	No	11	Iran	3
Darien	Yes	11	Uganda	4
Subeera	Yes	11	Uganda	4
Chris	No	12	Uganda	4
Eric	Yes	12	Congo	8
Grace	No	12	Uganda	4

15 hours of classroom observations were conducted during the COVID-19 pandemic to better understand the contexts of the science instruction and provide the situational analysis of the writing tasks. Table 1 provides the demographic information about the participants. All the participants in the study had a refugee background with an average of 4.5 years in the United States. Three of them had recently passed the state's English proficiency exam and the rest were still enrolled in the English language development courses for a minimum of 2 hours or more. Most ELs brought limited or interrupted experiences in learning science while they lived as refugees in a different country.

Ethnographically oriented semi-structured interviews (Spradley, 1979/2016) were designed using the situational analysis framework (Table 2) adapted from Biber and Conrad (2019). Although this framework is originally used for describing the situational characteristics of writing, it also helped structure the interviews with ELs. During the interviews, science writing tasks and personal writing experiences were comparatively discussed with writing experiences in the English classes. The students were specifically asked to describe the situational characteristics of the science writing tasks and their writing experiences, including any feedback given by the teacher or peers (RQ 1). Students were also asked to describe the writing practices in the English classes in comparison to the science writing practices (e.g., genres, writing processes) to investigate their understanding of disciplinary differences (RQ2). Adopted from register studies, the comparative discussions also included language use in different writing tasks, that is, vocabulary, sentence structures, and discourse organization (RQ 2). The interviews were analyzed deductively (top-down) using the same framework.

ELs' writing samples were linguistically analyzed to identify the use of complex linguistic structures. The summaries ($N = 73$) were analyzed in Antconc software (Anthony, 2019) while the conclusion analysis letters ($N = 6$) were analyzed manually due to their smaller size. Particularly, the linguistic analysis focused on three of the pervasive linguistic structures that register research highlighted: nouns, nominalizations, and noun phrases including pre- and post- modifiers.

The article progresses through three steps to describe the contexts of science writing and ELs' perspectives on writing and language. First, I provide a situational analysis of two sample writing tasks to describe the contexts of writing in forensics and oceanography courses. Next, I utilize the

Table 2. Situational analysis framework for writing in secondary schools.

Category	Operationalization
Topic	General domain (science, English etc.) Specific topics for writing
Participants	Individuals involved in the writing process directly or indirectly (addressor, addressee, onlookers, helpers, peers)
Relations among Participants	Interactions from the start to the end of writing between teacher-students or student-student Power dynamics/teacher authority Shared life experiences (Covid, challenges in home country)
Channel	Mode (writing) and medium (e.g., virtual, in-person)
Production Circumstances	Discussions on writing (length, genre, purpose, etc.); translating, revising, drafting, editing, and giving vs. receiving feedback
Setting	Place of writing (classroom, lab, home)
Communicative Purposes	Purposes of writing tasks

Adapted from Biber and Conrad (2019).

common lexico-grammatical forms associated with academic-scientific writing in register studies (i.e., nouns, nominalizations, noun phrases) to describe EL writing and the demands of the written science register. These two steps aim to answer the first research question from the researcher's perspective. Finally, I present ELs' discussions on the situational aspects of science writing and language use in their own words to understand their developing perspectives on the register of academic science writing. Such discussions in the interviews assisted in answering the second research question.

Findings

Situational contexts of science writing

All science teachers participating in the larger ethnographic study followed the state's science standards, which emphasized written communication of knowledge (NGSS Leads States, 2013). As the classroom observations showed, both science courses primarily engaged learners in short writing such as note-taking and copying, but also few extended tasks (longer than one paragraph). The two writing assignments were chosen as samples for a detailed situational (see Table 2) and linguistic analysis because they had relatively higher submission rates compared to the other assignments.

Article summaries

A list of articles identified by the teacher provided learners with options for reading in the oceanography class. The *topics* in the articles related to current scientific research and explorations in oceans (e.g., whales, arctic zones). The *communicative purpose* of the article summary assignment was to promote content learning by summarizing (e.g., Antarctic ice-shelves). Students had to type up the summaries at home due to the remote instructional mode during the COVID-19 pandemic (*setting*).

The *production circumstances* refer to how ELs accomplished their assignments from the beginning to the submission. This also includes the science learning and writing strategies that ELs developed independently or with teacher guidance to cope with the demands of science writing. The participants reported reading an assigned article multiple times to understand it. Since all the participants were multilingual learners in two or more languages, some reported using their linguistic repertoires to cope with the vocabulary and syntactic demands of science writing. For example, translating science texts into another language was a strategy that learners employed using Google Translate or automated translations on websites. For example, Hanife read the articles after translating them into Turkish, which she learned as a third language in Turkey as a refugee. Subeera, on the other hand, summarized the ones related to the animals that she was familiar with. All ELs had to look up the scientific meaning of many lexical items (e.g., hotspot -cell phones- vs. hot spots—earthquakes-). While revising and editing were part of the process, ELs had to utilize their existing skills to summarize the materials without any further support. The summaries were then submitted to Google Classroom and received some or little virtual feedback from the teacher (*channel*).

In these circumstances, the students engaged in writing as a solitary activity. The *participants* of the summary assignment consisted of the students themselves and their teacher. The pandemic conditions made the arrangements of collaborative writing experiences impossible since the instruction was delivered on Zoom. The teacher, or the *addressee*, provided brief instructions on the summary assignment, but did not model how to write summaries. Students either did not have any skills to write a good summary or used any prior experiences from the English classes. As to the *relationship between participants*, the teacher represented the authority and expert roles in such assignments mainly because students had limited knowledge of oceanography topics and science writing. Their limited access to the language in the articles as developing writers made them substantially dependent on the teacher.

Conclusion analysis letters

The conclusion analysis letter assignment in the forensics class was primarily about the findings from a white powder test that students conducted in the classroom (*topic*). This assignment differed from the article summary by its *communicative purpose*, which was to share the results of the test in a report letter hypothetically written to a school principal. Students were given a scenario that expected them to analyze and compare the chemical reactions of different white powders to identify a drug. After the experiment was conducted in the classroom, students typed their analysis letter in the class and at home (*setting*).

The *participants* of this assignment included the writers themselves, the teacher, an imaginary principal (external audience), and sometimes their peers for feedback purposes. This writing assignment was formulated as a scientific report in a letter format. For example, students were instructed to address the principal and focus more on the findings rather than the processes of the experiment. The only person who read these letters was the teacher, but unlike the article summary, this letter assignment involved more social processes with multiple audiences and drafts.

In this assignment, the *relationship* between the participants was very similar to the article summary assignment (i.e., expert and authority) since the same teacher taught both courses. The teacher was able to demonstrate his care of the ELs' learning and writing more effectively since the hybrid instructional mode allowed him to be physically available in the classroom. In the interviews, multiple ELs reported that they did feel confident enough to generate good questions in the class and preferred to talk to the teacher during the passing periods. Chris, however, specifically mentioned breaking down the scientific words into its morphemes to understand the meaning, a vocabulary learning strategy from the English language development class. The *production circumstances* of this assignment were also different from article summaries in that the teacher dedicated Wednesdays to learners' writing needs and provided more support in letter writing such as overall organization (e.g., opening). However, Grace commented that the feedback she received would not be specific enough, leading her to correct her mistakes based on what made sense to her.

With the descriptions based on the situational analysis framework (Biber & Conrad, 2019), it was evident that the science teacher integrated the science writing tasks in distinct ways. It also was apparent that students perceived these two writing tasks as socially situated activities at different levels (Lea & Street, 2006; Lillis & Scott, 2007). In the next section, the science writing tasks will also be linguistically analyzed to further answer the first research question.

Linguistic characteristics of EL writing samples

Table 3 provides a summary of the linguistic features of ELs' writing samples. The summary assignments are compared to the authentic science articles to better understand ELs' complex language use. The noun phrases included in this analysis are attributive adjectives and nouns used as pre-modifiers as well as prepositional phrases used as post-modifiers.

The student summaries included an average 63.6 words whereas the science articles contained an average of 901.4 words. There is a big difference between the assigned readings and the summaries. Therefore, all the linguistic features were normalized to per 100 words for easier analysis and comparison. A sample analysis of one participant's article summary is provided below to illustrate the use of these noun-based grammatical features to communicate scientific information (Excerpt 1).

Table 3. Total and normed frequency counts of complex linguistic features.

Sample Texts and Features	Total Word Count	Word Count (Mean)	Nouns (per 100 words)	Nominalizations (per 100 words)	Noun Phrases (per 100 words)
Scientific Articles (*N*=11)	9916	901.4	34.7	6.3	8.44
Summaries (*N*=73)	4647	63.6	33	5.9	9.23

Excerpt 1

Sample Article Summary

File Name: OC_SUM_Y_UG_11_4_F_AH_1.txtOriginal science article: Scientists pull living microbes, possibly 100 million years old, from beneath the sea
Nouns = underlined, Nominalizations = italicized, Noun phrases = bold, Source text use = highlighted

> Scientists found **buried and living microbes in the water**. First, a geomicrobiologist and his team took **a small quantity of clay samples**, put them in **sample bottles** and added **simple compounds called acetate and ammonium** to discover what life might be in the water. And the team removed **bits of clay** from the samples up to days later and dissolved it to find **any living microbes** — given **the *shortage* of food for them in the mud**. Secondly, But in those samples, in **the same amount of sediment**, there were no more than **1000 bacteria**. The biologists therefore had to create **advanced techniques including the use of chemical *tracers*** to determine if **contaminating seawater** entered the samples and creating a way to examine **very small amounts of cells and isotopes**. Finally, after **65 days** the microbes increased by **four orders of magnitude** to over **1 million cells per cubic centimeter**. Under **this *investigation***, the researchers don't know what **the gyre microbes** have been doing all **these millions of years**.

The frequency counts of the noun-based structures in the science articles and student summaries show similar tendencies. Despite the striking differences in length as well as ELs developing language proficiencies, the normalized counts of the nouns and nominalizations in the articles are only slightly higher in the articles than the student-written summaries, but students' summaries contain slightly more noun phrasal structures. The interviews showed that ELs struggled with reading and writing tasks notably. A closer analysis of the student writing samples and interviews indicated that ELs used chunks of texts and direct quotes from the source texts. ELs utilized near synonyms of many scientific and academic terms as well as tried to paraphrase long phrasal structures in their own words. However, even the writers who exited the ESL program used source texts heavily. Writing such summaries required them to develop specific skills such as gauging the meaning of synonyms (or near-synonyms), creating phrasal structures, and paraphrasing sentences by substituting the vocabulary with others without much meaning loss. Despite such efforts, the patchwriting signs in the summaries indicate the need for specific writing skills that should be addressed in the classrooms.

The manual analysis of conclusion analysis letters ($N = 6$) also demonstrated certain patterns in ELs' letter writing. For example, all students started with a greeting (Dear ...) and many ended with a closure (e.g., sincerely, thank you). Although not instructed, ELs often engaged the audience in the letter via the frequent use of the pronoun "you" and provided advice about students' lockers.

Excerpt 2

Conclusion Analysis Letter

Nouns = underlined, Nominalizations = italicized, Noun phrases = bold

> Dear Principal,
>
> I have tested some samples and I've seen **some *reactions*** that maybe teachers and you as a principal should pay attention to, Because they could be drugs but You couldn't know without testing them. For example the vinegar, This had a lot of **different surprising *reactions.***
>
> Some of them made the powder disappear, others melted and even changed colors and froze down. These are **real drugs** that could affect other **children's *lives*** and even get the school itself in trouble if they were ever sold here by **anonymous people**. These might affect anyone based on **the colors they were turning** and how they were reacting.
>
> As you can see that these **types of things** deserve to be paid **a lot of *attention*** to all the time.

In tandem with the purpose of the letter assignment, learners presented the results of their experiment, but still utilized their existing linguistic repertoires. Although very few nominalizations occurred, they

Table 4. Statements from ELs' conclusion analysis letters.

Participants	Student Writing Samples: Introducing Findings/Results
Participant #1	I writing this letter to inform you about **the test results of the unknown powders.**
Participant #2	Dear, school principal regarding **our finding from the unknown powder that we tested.**
Participant #3	**The results of my findings in the unknown powder** were very clear.
Participant #4	I am writing this letter in regards to **certain findings we have found on one of your student's locker, Noah Puckerman.**
Participant #5	The reason for my letter is to inform you which were **the results of the revision of the students lockers of your high school. The results of my findings in the unknown powder** were very clear .... **The results of the tests of the powders** make it easy for me to get the results of the unknown powder that was found in the locker #2718.
Participant #6	I have **tested** some samples and I've seen some reactions that maybe teachers and you as a principal should pay attention to.

were repeatedly used throughout the samples (e.g., reaction, results). The use of nominalizations was much lower than the article summaries (2.6 per 100 words). The manual analysis of noun phrase use also showed a similar pattern (7.2 per 100 words) when compared to the student summaries (9.23 per 100 words). Unlike the article summaries, the letters contained more general English vocabulary and fewer complex structures. A comparison of student writing to the original assignment prompt showed that students borrowed some noun phrasal structures directly from the assignment scenario (e.g., **unknown** powders, **white** powder, **chemical** tests) or constructed new phrasal structures (e.g., **different** reactions, **certain** findings, **real** drugs) that included attributive adjectives. However, student-constructed phrasal structures are less precise and not discipline-specific compared to the borrowed examples.

How ELs accomplished the purpose of the letter writing assignment (i.e., to communicate the results of an experiment) provides insights into their existing linguistic repertoires as well as their needs in writing. Learners were supposed to communicate how they identified the drug from other white powders, not the procedures of the experiment. Most ELs successfully introduced the experiments using nominalizations such as "finding(s)" and "result(s)." They also constructed phrasal structures such as prepositional phrases and nouns as modifiers to specify the information they were communicating (e.g., the **test** results **of**, findings **from the unknown powder**, the results **of my findings**). The wide variety of such structures that ELs utilized for conveying the information is further illustrated noted on Table 4.

The examples from the EL writings show ELs' need for linguistic support to introduce the findings such as noun phrases for scientific details as well as their strengths as writers using their language repertoires. Constructing noun phrasal structures for precision may present challenges to ELs since such structures create long strings of vocabulary that render the meaning abstract and complex. Additionally, EL writers referred to the findings/results with a variety of verb choices that might be highly frequent non-academic types common in conversation, fiction, and news instead of academic writing such as "be, come, make, have, do" (Biber et al., 2021). For example, Participant 5 used the verb "be" and an adjective in a subject predicate position (The results of my findings in the unknown powder were **very clear**.). The use of verbs along with noun phrases to introduce the results/findings may be considered as a productive discussion topic in letter writing. Teachers might model the construction of noun phrases and the use of more academic verbs for more objective and less evaluative information-sharing such as *confirmed* or *indicated* or the verbs related to changes such as *become, get, turn, end up*, and *grow*" among others (Biber et al., 2021) to discuss chemical interactions observed during the experiment. ELs' attempts to employ a variety of structures to accomplish their writing goals is a sign of their developing awareness of academic science writing and a strength for their language development since they actively employ their linguistic repertoires in meaning making.

In summary, the situational and linguistic analyses of the two writing tasks above described the characteristics of two writing situations and learners' language use via the Register-Functional

Framework used in register studies (Biber & Conrad, 2019). In the article summary task, the learners had to read and summarize a dense science article while, in the conclusion analysis letter, they had to observe the chemical reactions and construct a letter that focused on the results. ELs utilized complex structures in the summary task which were directly taken from the source articles while some EL writing showed substantial paraphrasing efforts. ELs' letters, on the other hand, demonstrated less use of such complex structures. ELs received some guidance on the structure of letters, generated drafts of a letter, and received verbal feedback from the teacher, thus making the conclusion analysis letter a more socially situated writing activity (Lea & Street, 2006; Lillis & Scott, 2007). The outcomes of both writing tasks indicate ELs' developing strengths in language use (e.g., translating, paraphrasing, finding synonyms, constructing noun phrases) as they developed their academic literacies in the science discipline and transitioned into the disciplinary writing and language practices. The following section will discuss ELs' understanding of the register of science writing by bringing their perspectives on science writing and language (RQ 2).

Experiences and perspectives on academic science writing

During the interviews, the participants were asked questions related to the situational characteristics (e.g., purpose, audience) and language use (e.g., scientific vocabulary) in science and English writing tasks. For example, I asked, how is writing in science or English different or similar? Can you talk about the language you use in the writing tasks in these subjects? For an ethnographic description of experiences, the students were requested to provide as much information as possible.

The discussions included a dominant theme related to science and English classes: the length of writing. While both disciplines include shorter and longer writing tasks, the most obvious characteristic of the science subject was shorter writing tasks. For instance, Darien asserted that science involved short writing and said: "In English, we have to write longer things. In forensics, the paragraphs are shorter because it is science, not English." Eric was also confident that the teacher did not care about length at all. His statement, "[In English] You're going to make sure you are [writing] big letter, you know, to get like a lot of points or to impress your teacher." implies that the expectations of longer writing in English make writers believe that extended writing is more impressive and helps earn better grades. Both students associated short writing with science courses (e.g., worksheets), which reflects the influence of shorter writing on their understanding of science writing. The writing tasks in science generally required 1–2 paragraphs and such writing mostly expected writers to use classroom materials to answer short comprehension questions rather than construct new knowledge or thoughts on scientific topics. An exception was the GMO argumentative essay in biology that required using external sources and building an argument to persuade the reader. On the other hand, extended forms of writing in English (e.g., essays, memoires) required more elaboration on writers' thinking, genre knowledge (e.g., argumentation, persuasion), and expressions for rhetorical effect, creating different impressions of disciplinary writing across science and English classes.

Another theme that surfaced in the conversations related to the circumstances of writing in science writing tasks as opposed to English classes. Chris noted the absence of discussions on genre structure and sentence elaboration in science classes. This difference could be attributed to the perceived simplicity of short writing, which might have led both the teachers and students to overlook the potential for conversations on writing. A comment from Subeera's seemed to support this, "[In science] We don't write about like an argumentative writing," suggesting that discussions on how to write argumentation differentiated between science and English classes. Grace shared a similar perspective on writing, "Science [writing] is more about what you saw, but in English you have to like to persuade a person ... " Such statements might not accurately describe the science community and its writing practices. Yet, the lack of exposure to argumentative genres, longer writing expectations, and discussions on writing specific thoughts and arguments likely affected ELs' perspectives in unexpected directions.

During the interviews, when the ELs were prompted to discuss the linguistic demands and their language use in science and English writing, their responses suggested how their awareness of registers was growing. Maira, for instance, implied the specificity of scientific vocabulary, "In science, there is a lot of new words you do not know about. You cannot talk about what is happening [with specificity/precision]." On the other hand, Eric emphasized the functions of language by referring to the accuracy and persuasive use of language in English although he also argued that such focus did not occur in science classes, "English is about language ... writing actual right things [accuracy]. In English, you got to focus vocabulary." Moreover, Rana said, "In science, grammar does not matter." Although register studies found that the use of syntactic structures such as phrases for information packaging, precision, and elaboration in the written science register, ELs might not necessarily articulate yet the relevance of such forms to science writing. It is likely that the heavy technical vocabulary drew their attention to the lexical aspects more than syntactic and discourse level features of science writing. Combined with the observed emphases on academic and scientific vocabulary learning in the classrooms, the students seemed to have developed a sensitivity to vocabulary, but not grammatical structures, which shows the developing nature of ELs' register awareness (Biber & Conrad, 2019) and academic literacy (Lea & Street, 2006).

Discussion

The goal of this ethnographically oriented study was twofold: to investigate the situational and linguistic characteristics of two science writing tasks with a register-functional perspective (RQ1) and explore ELs' developing awareness of the register of academic science writing (RQ2). The analysis of the writing situations assisted in describing the landscape of secondary science writing practices. The linguistic analysis, on the other hand, helped identify EL writers' strengths and needs in L2 writing based on the prominent features of academic science writing (Biber & Conrad, 2019). The situational framework, also used to answer the second research question via interviews, helped unpack ELs' thoughts on disciplinary writing and language demands in science and English classes, providing an exploratory perspective on ELs' developing academic literacies (Lea & Street, 2006) and academic register awareness (Biber & Conrad, 2019).

The situational and linguistic analysis of writing samples (RQ 1) illustrated how fundamentally the summary and conclusion analysis letters differed from each other and how linguistic demands in science writing are closely related to the writing situations. The two writing tasks showed different situational and linguistic characteristics such as communicative purposes (i.e., to summarize key information vs. present a conclusion), the participants (self, peers, addressee), and the circumstances of writing. Writing in multiple genres with situational differences required ELs to embed the lexical and grammatical forms demanded by the situational variables. The participants in this study accomplished the writing tasks and the linguistic demands by using their growing linguistic repertoires (e.g., gauging language appropriateness, translating, using first or home language) while they reported challenges associated with the complexities of language. Sensitivity to vocabulary demands in science (e.g., technical vocabulary) was evident in learners' conversations, but when it comes to the grammatical structures related to the register of science writing, ELs discussions implied specific details or precision needed in writing, which refer to the functions of noun phrases with pre- and post-modifiers (e.g., attributive adjectives, prepositional phrases) and nominalizations. Therefore, a focus on raising ELs' consciousness about such prevalent linguistic features in science writing might help them construct such structures more capably. While building their academic literacies and register awareness, developing writers could successfully switch between everyday language and the academic register across disciplines (Lea & Street, 2006; Lillis & Scott, 2007).

ELs' discussions of writing and language illustrate a relationship between writing practices in content classrooms and awareness of academic register. ELs might experience writing differently across subject areas due to the specialized practices of each discipline (Moje, 2008), and thus develop a personal understanding of disciplinary language and writing. For example, based on their

experiences in two science classrooms (e.g., solitary writing, limited discussions on writing, genres lacking interpretation and arguments), ELs perceived science writing as primarily concerned with communicating observed patterns or facts rather than incorporating argumentation. Additionally, practicing writing (e.g., iterative writing experiences like drafting and revisions) was not associated with science writing. Although communicating information is a common expectation in the educational standards (NGSS Leads States, 2013), it is likely that the lack of emphasis on the language of science communication through authentic audiences and mentor texts led to an understanding of science not incorporating such practices. Writing practices in science could therefore integrate more thinking in the tasks through argumentation, reflection, and the analysis of the scientific phenomena more frequently instead of using writing as a recall and recording method (Applebee & Langer, 2015; Lent, 2015; Nachowitz, 2015). Such disciplinary writing practices benefit ELs' academic literacy development if the language of the science community is integrated into science education (Fang & Coatoam, 2013; Moje, 2015) and ELs' linguistic needs are simultaneously accommodated by teachers.

Science education and literacy scholars posited that ELs would benefit from direct instruction, modeling of the language, and co-constructing (de Oliveira, 2008; de Oliveira et al., 2021; Huerta & Garza, 2019). To scaffold instruction with such practices, science and EL educators might collaborate on how to center writing support on precision, accuracy, and clarity. School-aged writers usually learn grammatical features vital for compressed science communication (e.g., nominalizations and noun phrases) in the secondary grades with more intensive content instruction, so teacher collaboration might make cross-disciplinary transitions into different writing genres smoother for ELs. Metalinguistic conversations about language and textual structures may also help ELs comprehend complex information and increase their level of engagement in science classrooms (Palincsar & Schleppegrell, 2014). For example, mini lessons about how mentor texts communicate information might embed such metalinguistic conversations without diverting the focus of lessons substantially (e.g., how to write experiment results). Similarly, students' writing samples from past years might serve as examples or mentor texts for developing writers. With more critical language awareness on science communication, EL writers might integrate complex structures in their writing.

Conclusion and limitations

The purpose and methodological approach in this study position all learners including ELs as agents who construct an awareness of language use in science writing, not as passive recipients. Therefore, ELs' perspectives on writing and language provide valuable insights into content area teaching. Educators of ELs should reconsider their roles in school settings to support written communication, an emphasis placed by educational standards for all educators of ELs (Kibler, 2013; Valdés et al., 2014).

With its emphasis on ELs' writing samples and perspectives on disciplinary writing practices, this study responds to the calls for studies documenting ELs' writing histories and instructional issues in secondary schools that might inform postsecondary writing practices as well as disciplinary literacy development (Grujicic-Alatriste & Grundleger, 2020). Moreover, the evidence regarding the use of writing in science classrooms corroborates the findings of earlier writing studies that revealed secondary level learners' limited use of extended writing tasks and scarce guidance on writing (Applebee & Langer, 2011; Drew et al., 2017). This study also illustrates how the register of academic science writing could inform disciplinary writing practices by revealing the situational characteristics and the linguistic demands of tasks for EL writers.

This study was limited by the restrictions caused by the COVID-19 pandemic. Longer and more systematic observations of ELs in science writing situations could provide deeper insights into ELs' writing experiences. During the pandemic, fewer writing assignments were submitted by all learners including ELs such as the conclusion analysis letters. ELs' individual circumstances (e.g., bus transportation, after-school work) placed restrictions on the length of the interviews as well. Future research focusing on ELs' linguistic choices in science writing tasks could incorporate discussions on those patterns of grammatical choices to better understand their decision-making processes and

register awareness, which is an interview model also known as discourse-based interviews (Lancaster, 2016; Odell et al., 1983).

Finally, culturally and linguistically responsive researchers and teachers of ELs must listen to ELs' needs more deliberately to inform secondary writing practices. It is my firm belief that by bringing learners' lived experiences and linguistic needs to teachers' attention, ethnographically oriented literacy research may further contribute to science writing and teacher education.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The work was supported by the Research and Project (ReaP) Grant by the Graduate and Professional Student Council at the University of Arizona.

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