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Exploring English Language Learners' Performance on Online, Asynchronous Science-Based Examinations

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ABSTRACT

This study explored the relationships between English language proficiency and performance in online, asynchronous science courses. Each participant completed a Language Background Questionnaire (LBQ) to indicate if English was not their native language, thus categorizing them as an English Language Learner (ELL). The Combined English Language Skills Assessment (CELSA) measured English language proficiency. Of 25 ELLs 13 were interviewed to elicit their perspectives of learning strategies used in an online environment. Quantitative analyses involved t-tests and Pearson's correlation among 91 participants' CELSA scores and final exam results. For non-ELL students, there were weak to moderate, positive correlations for Bacteriology 2: $r(57)=.47$, $p<.00$, Clinical Chemistry 1: $r(33)=.36$, $p=.04$, and Clinical Chemistry 2: $r(33)=.44$, $p=.01$; no other significant correlations were found. This study may inform interventions and strategies that enhance learning and performance in science-based coursework in courses taught in asynchronous, online programs for all students, particularly ELLs.

KEYWORDS

English Language Proficiency, Online Education, Science Education, Assessment

INTRODUCTION

The popularity of online learning has risen steadily over the past decade, accelerated by the COVID-19 pandemic (National Center for Education Statistics, 2023). The flexibility of online education has driven its growth, with many institutions expanding their virtual course and degree offerings to meet demand. While less than 25% of students were enrolled in online courses before 2012 (Hamilton & Beagle, 2024), by 2021, more than 50% were taking some online courses, and 26% were fully online.

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English Language Learners in Higher Education

Higher education institutions are increasingly under pressure to graduate professionals prepared to address shortages in essential, in-demand fields like healthcare. According to the U.S. Bureau of Labor Statistics (2024), healthcare industry jobs are projected to grow by 16% over the next decade, adding 2.6 million new positions. As the U.S. population becomes more racially, ethnically, and culturally diverse, increasing the diversity of the healthcare workforce is vital for delivering tailored, equitable, and high-quality care (National Institutes of Health, 2022). Diversifying healthcare professions may be achieved through targeted recruitment of immigrants and international students.

Most health professional programs require proficiency in English reading, writing, math, and critical thinking skills, which can pose challenges for English language learners (ELLs). ELLs include recent immigrants from countries where English is not the primary language of instruction, international students studying in higher education institutions, and individuals from "Generation 1.5," who arrived in the United States as children or teenagers but whose parents speak a language other than English at home (Bergey et al., 2018). ELLs comprise nearly 20% of the college population (Fishman et al., 2017; Hussar et al., 2020). It is estimated that 10% of all public school students are ELLs (Hussar et al., 2020), 18% of incoming college students are non-native English speakers (Fishman et al., 2017), and international students make up approximately 5.6% of the higher education institution population (Knox, 2023). This diverse group of learners faces unique challenges, particularly in asynchronous online environments (Bogunovich, 2018).

English Language Learners in Online Learning Environments

Previous research indicates that ELLs tend to underperform on in-person exams, partly due to English proficiency barriers (Lakin et al., 2012). Lakin et al. noted that English proficiency may negatively influence ELL performance on tests primarily intended to assess their content knowledge and skills. These challenges may be further exacerbated in science-based courses due to the complexity of the language used in teaching and assessment (Lee & Avalos, 2002). Several accommodations have been considered and implemented to mitigate these barriers and reduce the disadvantage to ELL students. Abedi et al. (2000; 2004) have extensively discussed assessment accommodations for ELLs, particularly in science and mathematics in secondary education. Kieffer et al. (2009) demonstrated that providing English dictionaries or glossaries significantly improved ELL test performance. Marinho et al. (2023) noted that English language accommodations often involve simplification, repetition, and clarification. However, the resources needed for ELLs in higher education post-matriculation remain largely unexplored (Harrison & Shi, 2016). Consequently, more research is required to determine the appropriate accommodations for ELL students in higher education.

A significant challenge of asynchronous online learning is that students must work independently without face-to-face faculty and peer interaction. Studies have shown that ELL students benefit from more interactive activities aimed at expanding their language use, particularly discipline-specific language, than their peers (Billings & Mueller, 2017). These types of learning activities may be lacking in an asynchronous online environment, creating a potential learning barrier for ELL students. Additional language-related obstacles in asynchronous online assessments may hinder ELL achievement (Andrade, 2014). For example, cultural differences and underdeveloped English skills may negatively impact ELLs' test performance, especially in science courses requiring complex language (Bogunaovich, 2018). Asynchronous online assessments also differ from in-person exams, where instructors can directly address questions, presenting further challenges for ELLs.

Current literature on ELL performance in online learning environments is limited. A practical theory of transactional distance, described by Moore (1997), highlights a pedagogical challenge that occurs when instructors and students are separated by space, time, or both. Stein et al. (2005), using Moore's theory of transactional distance, found that students' perceived knowledge gain and satisfaction increased with more opportunities to interact with instructors in distance learning environments. However, they did not evaluate assessments or ELLs specifically. Andrade (2014)

applied the theory of transactional distance and the theory of self-regulated learning to ELLs in online education, suggesting that formats encouraging socialization between students and instructors in online classrooms empower ELLs to improve their English language skills and course performance. However, studies investigating effective asynchronous online strategies, particularly in science courses, to support ELLs' success remain limited.

As asynchronous online education expands, often driven by student demand, ELLs face compounding challenges in succeeding independently with limited faculty support. This study aimed to determine whether asynchronous online assessments pose significant obstacles to ELLs in health professional science courses and to gain direct insights from ELLs regarding specific challenges they encounter in these courses. The specific aims of the study were to (a) compare comprehensive final exam scores in asynchronous online medical laboratory science courses between ELL and non-ELL students, (b) evaluate the relationship between English language proficiency and final exam performance for ELL students, and (c) explore ELL students' perceptions of learning and assessment in asynchronous online courses, including the impact of faculty support during exams, through qualitative interviews. Given that ELLs comprise nearly 20% of the college population and face distinct challenges in asynchronous online courses, including high-stakes assessments traditionally conducted in person, it is essential to develop supportive methods for this student population (Fishman et al., 2017; Hussar et al., 2020). The findings of this study may inform practices to improve equity and outcomes for linguistically diverse students in asynchronous online learning environments in higher education.

METHODS

Research Design

The study employed a mixed-methods, longitudinal approach conducted over three academic semesters: Fall 2021, Spring 2022, and Summer 2022. Two quantitative instruments were included: the Combined English Language Skills Assessment (CELSA), which provides a single numerical score (0–75) per attempt (ACTT, 2018), and final examination scores for six asynchronous online courses: Clinical Biochemistry 1 and 2, Bacteriology 1 and 2, and Hematology 1 and 2. These courses were selected because they are required for all students in both undergraduate and graduate programs within the department and because their examination questions are written in a style and format similar to those found in professional certification examinations.

Qualitative measures included a language background questionnaire (LBQ) and a semi-structured interview protocol. To participate in the study, students had to complete a brief intake form and schedule a meeting with a study team member to complete the LBQ and CELSA. The study received institutional review board approval (NCR202864), and all participants provided informed consent before completing the LBQ and CELSA and allowing the retrieval of their final examination scores.

Study Population and Sampling

The study population comprised students enrolled in undergraduate or graduate-level academic programs at a U.S. university offering bachelor's degrees, post-baccalaureate certificates, and master's degrees in biomedical laboratory sciences. Enrolled students may already hold an associate's or bachelor's degree, are typically employed full-time while pursuing their studies, and may work in clinical settings, such as diagnostic laboratories, research facilities, or emergency medical services.

Matriculants were required to demonstrate English language proficiency through one of the following: (a) citizenship in a country where English is the official language, (b) possession of a bachelor's degree from a country where English is the official language and language of instruction, (c) possession of a bachelor's degree from an institution accredited by a U.S. regional accrediting agency, or (d) achieving a minimum score on a standardized English language proficiency test (e.g.,

Test of English as a Foreign Language, International English Language Testing System, or Pearson Test of English).

In week 4 of the specified courses, an announcement detailing the study was posted on the university's learning management system (LMS), followed by two subsequent reminders. Interested students were directed to an online intake form to provide their name and email address (see Appendix A). Upon completing the intake form, participants received a link to schedule a Zoom meeting with a study team member to complete the LBQ and CELSA.

Participants who completed the LBQ and CELSA were compensated with a $30 gift card and were awarded three extra credit points on their course final examination. Non-participating students could also earn three extra credit points by completing an alternative, voluntary course-related assessment. Additionally, participants in the qualitative interviews received an additional $25 gift card as a token of appreciation.

Data Collection

A one-hour meeting via Zoom was conducted with each participant who scheduled an interview with a study team member. A copy of the informed consent was attached to the confirmation email sent by the study team member before the meeting. During the meeting, participants were given the opportunity to ask questions about the study before being provided with a link to the LBQ in Qualtrics via Zoom's chat feature. The informed consent text was also included at the beginning of the LBQ, and informed consent was assumed if the participant proceeded to complete the questionnaire.

The LBQ was a modified version of the open-source Language Experience and Proficiency Questionnaire to collect data on participants' demographic characteristics and language experiences. These included the acquisition, dominant use, and self-rated proficiency in reading, understanding, and speaking English versus their native language (Marian et al., 2007). Modifications to the LBQ included adding questions about country of birth/origin and the use of English and other languages at home, school, and work for those who self-identified as ELLs (See Appendix B).

After completing the LBQ, a study team member used Zoom's screen-sharing and mouse control features to administer the CELSA through a licensed, computer-based application. The CELSA, a nationally recognized assessment, measures English reading comprehension and grammatical ability based on contextual understanding (National Reporting System for Adult Education, 2020; see Appendix C for sample questions). Participants' raw scores (0–75) from the CELSA were collected for this study.

Final examination scores, excluding extra credit awarded for participation, were retrieved from the Grade Center in the LMS for each participant who completed the LBQ and CELSA. These scores corresponded to six asynchronous online courses (Clinical Biochemistry 1 and 2, Bacteriology 1 and 2, and Hematology 1 and 2) taken during the study period (Summer 2021, Fall 2021, and Spring 2022). Participants were enrolled in one, two, or all three courses depending on their program of study and entry point into the program. The final exams, which were content-specific, time-limited, remotely proctored, and asynchronous, consisted of multiple-choice questions designed to assess students' proficiency in the subject and predict their ability to pass professional certification exams.

For the qualitative phase, audio-recorded, semi-structured interviews were conducted in English via Zoom with a subset of ELL participants. These interviews explored participants' experiences and perceived facilitators and barriers to learning and assessment in an asynchronous, online environment. A member of the study team (LS) conducted the interviews using a protocol (see Appendix D) developed through iterative discussions among the authors (CR, RG, CC, YB, MF, and LS). All authors are full-time faculty who teach science-based courses in asynchronous online programs. One author (RO) is a nurse enrolled in a post-baccalaureate pre-medicine program for career changers. While most authors (CR, CC, MF, and LS) were born in the United States and consider English their native language, three authors (RO, RG, and YB) were born outside of the United States and identify other languages as their native language.

The semi-structured interview protocol included questions about participants' introduction to learning English, prior work in a science-based field, strategies for learning course material and preparing for exams, and recommendations for supporting students with varying degrees of English proficiency in asynchronous online classrooms. These questions were aligned with the study's aims to examine the benefits and challenges of learning in an asynchronous online environment for ELL students and to identify instructional strategies to support their learning.

Data Analysis

Data collected through the online LBQ survey were downloaded from Qualtrics and put into an Excel spreadsheet. CELSA scores and content-specific multiple-choice examination scores were matched with the corresponding LBQ responses using unique identifiers. Statistical analyses, including independent *t*-tests and correlations, were conducted to examine relationships between CELSA scores and content-specific final examination scores using SPSS version 27.0.1.0 (IBM Corp., Armonk, NY, USA) statistical software.

Transcripts from the recorded interviews were auto-generated using Zoom's transcription feature and subsequently checked for accuracy against the recordings. All identifying information was removed, and the cleaned transcripts were uploaded into NVivo version 20.4.0 (QSR International, Burlington, Massachusetts, USA) qualitative data analysis software. Following the iterative methodology for qualitative data analysis, interpretation, and presentation outlined by Merriam and Tisdell (2015), transcripts were coded by two study team members (RO and LS). RO coded six transcripts, while LS coded the remaining seven.

The development of the codebook began with deductive codes derived from the interview questions, while additional inductive codes emerged from the data. The coded data were reviewed across participants, leading to the identification of themes. Consensus on coding and themes was achieved through collaboration between RO and LS to ensure trustworthiness in the analysis.

RESULTS

A total of 94 unique students completed the intake form, and 91 participants (79% female, aged 22–51) completed both the LBQ and CELSA. Of these, 27 participants (30%) reported no previous healthcare experience, while 22 (24%) were medical laboratory technicians, and 42 (46%) had worked in other healthcare professions before enrolling in their current academic program. Participant characteristics are summarized in Table 1.

Table 1. Participant characteristics

Characteristic	Count	Percent
Total participants	91	100%
Gender		
Female	72	79%
Male	18	20%
Other (not specified)	1	1%
Highest education level		
Associate's degree (2-year degree or equivalent)	11	12%
Bachelor's degree (4-year degree or equivalent)	49	54%
Some graduate school	12	13%
Master's level degree	13	14%
PhD/EdD/MD/JD	6	7%

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Table 1. Continued

Characteristic	Count	Percent
Worked in other healthcare profession prior to MLS program		
No previous training or experience	27	30%
Emergency medicine technician (or equivalent)	3	3%
Medical doctor (or equivalent)	1	1%
Medical laboratory technician (or equivalent)	22	24%
Other healthcare profession	38	42%
Can speak or understand another language other than English		
Yes	54	59%
ELL	25	46%
non-ELL	29	54%
No	37	41%

Note. N = 91, PhD = doctor of philosophy, EdD = doctor of education, MD = doctor of medicine, JD = doctor of jurisprudence, MLS = medical laboratory science, ELL = English language learner.

Based on LBQ responses, 25 participants (27%) self-reported that English was not their native language and were identified as ELLs. Of these 25 ELL students, 13 (52%) agreed to participate in an audio-recorded interview via Zoom with a study team member. Table 2 presents the demographics of the interview participants.

Table 2. Demographics of interviewed English language learner (ELL) participants

Gender	11 female, 2 male
Age range	25–49 years
Other healthcare experience	All but one; MLT, EMT, MD, CNA, MA
Native language	Arabic, Cantonese, Chinese, Gujarati, Korean, Luo, Malayalam, Mandarin, Swahili, Spanish, Tagalog, Vietnamese
Speak native language at home	● Never (3) ● Sometimes (0) ● About half the time (1) ● Most of the time (4) ● Always (5)
Age upon arrival in United States (range)	4–27 years; one born in the United States
ELL category	● Arrived in the United States as a child or teenager and have learned sufficient English so that I can communicate in both English and my native language (5) ● Immigrated to the United States as an adult from another country for better economic, political, or social opportunities (5) ● International student in the United States to improve my English, take courses, or obtain a certificate or degree from this U.S. institution (1) ● Did not respond (2)

Note. MLT=Medical Laboratory Technician, EMT = Emergency Medicine Technician, MD = Medical Doctor, CNA = Certified Nurse Assistant, MA = Medical Assistant; ELL = English language learner.

As outlined below, multiple statistical analyses were conducted to address the first two research questions regarding relationships between CELSA scores and final examination scores for ELL and non-ELL participants.

ELL Status and Final Examination Scores

Independent *t*-tests were conducted to determine whether the mean final examination scores of ELL students were significantly lower than those of non-ELL students across all courses. No significant differences were found. The results of all comparisons are provided in Table 3.

Table 3. Comparison of final examination scores between English language learners (ELLs) and non-ELLs

Course	Mean (*SD*)	*t* (assuming equal variances)	Sig. (1-tailed)
Bacteriology 1			
ELL ($n = 21$) non-ELL ($n = 57$)	74.46 (8.27) 76.18 (7.99)	–0.83	0.21
Bacteriology 2			
ELL ($n = 19$) non-ELL ($n = 57$)	88.54 (6.86) 88.27 (8.06)	0.13	0.45
Hematology 1			
ELL ($n = 14$) non-ELL ($n = 27$)	80.01 (6.94) 79.83 (9.91)	0.06	0.48
Hematology 2			
ELL ($n = 14$) non-ELL ($n = 27$)	79.86 (9.25) 80.11 (8.92)	–0.09	0.47
Clinical Chemistry 1			
ELL ($n = 12$) non-ELL ($n = 33$)	88.10 (8.65) 88.51 (6.79)	–0.17	0.43
Clinical Chemistry 2			
ELL ($n = 12$) non-ELL ($n = 33$)	89.42 (6.03) 85.39 (8.06)	1.58	0.06

Note. SD = standard deviation, ELL = English language learner, Sig. = significance.

CELSA Scores and Final Examination Scores Based on ELL Status

The Pearson correlation coefficient was used to examine the relationship between the CELSA score for each of the 25 ELL participants ($M = 69.20$, $SD = 5.78$) and their final examination score(s), depending on the course(s) in which they were enrolled. No significant correlations were found among ELL students. The results of all comparisons are presented in Table 4.

Table 4. Correlations between combined English language skills assessment (CELSA) scores and final examination scores for English language learners (ELLs) only

Course	*n**	Pearson correlation coefficient (*r*)	Sig. (2-tailed)
Bacteriology 1	21	–0.07	0.75
Bacteriology 2	19	0.05	0.85

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Table 4. Continued

Course	*n**	Pearson correlation coefficient (*r*)	Sig. (2-tailed)
Hematology 1	14	–0.22	0.45
Hematology 2	14	–0.27	0.36
Clinical Chemistry 1	12	0.01	0.97
Clinical Chemistry 2	12	–0.14	0.67

Note. Sig. = significance.
* *n* represents the number of ELLs for which there was a CELSA score and a final examination score in the course.

The relationship between the CELSA score for each of the 66 non-ELL participants (M = 72.85, SD = 2.23) and their final examination score(s), depending on the course(s) in which they were enrolled, was examined by calculating the Pearson correlation coefficient. Unexpectedly, weak to moderate positive correlations were found for Bacteriology 2: $r(57) = 0.471$, $p < 0.00$, Clinical Chemistry 1: $r(33) = 0.363$, $p = 0.04$, and Clinical Chemistry 2: $r(33) = 0.437$, $p = 0.01$; no additional significant correlations were found among non-ELL students. The results of all comparisons are listed in Table 5.

Table 5. Correlations between combined English language skills assessment (CELSA) scores and final examination scores for non-English language learners (ELLs)

Course	*n**	Pearson correlation coefficient (*r*)	Sig. (2-tailed)
Bacteriology 1	57	0.288	0.03**
Bacteriology 2	57	0.471	< 0.01**
Hematology 1	27	0.310	0.12
Hematology 2	27	–0.075	0.71
Clinical Chemistry 1	33	0.363	0.04**
Clinical Chemistry 2	33	0.437	0.01**

Note. Sig. = significance.
* *n* represents the number of non-ELLs for which a CELSA score and final examination score in each course were available.
** Significant at the $p < 0.05$ level.

Yet additional analyses between the CELSA scores for all 91 students (M = 71.85, SD = 3.94) and final examination scores for the courses they enrolled in found no significant correlations (see Table 6).

Table 6. Correlations between combined English language skills assessment (CELSA) scores and final examination scores for English language learners (ELLs) and non-ELLs combined

Course	*n**	Pearson correlation coefficient (*r*)	Sig. (2-tailed)
Bacteriology 1	78	0.135	0.24
Bacteriology 2	76	0.217	0.06

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Table 6. Continued

Course	*n**	Pearson correlation coefficient (*r*)	Sig. (2-tailed)
Hematology 1	41	0.038	0.82
Hematology 2	41	–0.151	0.35
Clinical Chemistry 1	45	0.183	0.23
Clinical Chemistry 2	45	0.121	0.43

Note. Sig. = significance.
* *n* represents the number of non-ELLs for which a CELSA score and final examination score in each course were available.

Qualitative Interviews

Thirteen ELL students participated in interviews that focused on their academic preparation and experiences learning in an online environment. The results of the thematic analysis of the interview transcripts are summarized below.

Experience With English

Participants were first asked to describe their overall experiences learning English, leading them to share their country of birth, academic paths, and previous health-related work experiences. Participants immigrated to the United States as children, teenagers, or adults for various reasons, including the desire to attend college in the United States. The primary influences on their language development included parents, teachers, and peers. Participants' experiences with learning and using English varied. Some were exposed to English at a young age, particularly if their parents spoke both English and their native language, while others only encountered English when they began their academic career, whether in primary, secondary, or post-secondary education. Some participants noted that their focus was more on grammar than conversation. For instance, Participant 2 shared:

> *In Korea, you learn English in school starting in third grade, like ABC and simple vocabularies and singing songs and stuff like that, so… it wasn't something new to me. But we tend to focus more on grammar stuff rather than speaking or listening or your conversation skills. So grammar-wise, I was pretty okay ever since I came [to the United States], but then, you know, the speaking and listening, those were the things that give me a little hard time.*

Benefits and Challenges of Online Learning

Participants were asked about their perceived benefits and challenges in learning in an asynchronous online environment. Nearly every participant mentioned the flexibility of online learning as a benefit. The self-paced nature of asynchronous learning allows full-time working students to study at their own time and pace. Participant 12 stated:

> *[Taking courses asynchronously online] allows me to use my time more flexibl[y], and it also teaches me how to better use my time when I'm working a full-time job and also trying to assimilate everything online, so it's definitely taught me to use my time wisely.*

Additionally, several participants highlighted the benefit of having pre-recorded lectures, allowing them to watch at 1.5x speed, pause, take notes, and rewatch content multiple times.

However, a lack of direct contact with the professor was frequently mentioned as a challenge in the asynchronous online learning environment. Most students found it difficult not to have the professor available synchronously or in real time while taking a test, as they could not ask questions or clarify the intended meaning of words. The majority of participants noted that they could only ask questions about their exams after grading. Participant 2 shared:

> *We have this asynchronous environment where we can't be with instructors in real time, and we have questions when taking the quizzes or have [a] question about the wording. We can't*

do that, and then after we've taken those exam[s] and quizzes, we asked about those wordings; then it is just too late.

Similarly, the inability to apply concepts through hands-on activities was also noted as a challenge. In courses like chemistry and microbiology, the lack of physical lab work—such as performing reactions in test tubes or examining organisms under a microscope—was considered a limitation. For example, Participant 44 stated: "When it comes to science, it's really a lot of hands-on, like lab work. I'm in the medical laboratory science program, and I cannot really do hands-on; I'm just relying on videos on YouTube." A few participants mentioned that not having a dedicated workspace at home for taking tests affected their experience in the asynchronous, online environment, unlike in-person classes where tests are conducted in suitable spaces like classrooms or testing centers.

Learning and Study Strategies

Participants were asked about their learning and study strategies in in-person and asynchronous online environments. Many described using similar methods for both formats, such as making flashcards and taking notes during lectures. Interestingly, one student mentioned translating content back into their native language when studying, particularly for complex concepts:

So, I use a lot of mnemonics. So, if I have to remember a list of bacteria, I will try to make it into… for example, for clinical biochemistry, when they have to memorize like the HDL, I made it into a sentence to help me memorize. If something is a little bit difficult to understand, … I'll use translation to help me to put it in my native language to have a better memorization of what that really means. (Participant 69)

In contrast, Participant 84 preferred to use English while studying:

I do write everything down in English when I'm listening to a lecture. Like yesterday, I had an assignment, reading an article, answering questions, so I just write all the points; all those are in English.

Similarly, Participant 57 noted that writing notes while reviewing pre-recorded lectures helped with studying: "[I] have to write everything with hands, which makes studying and memorization easier because you're using your motor skills, your memory, and everything."

Finally, students were asked what strategies instructors could introduce into asynchronous online courses to support ELL students' learning. Overall, ELLs highlighted that VoiceThread (an interactive LMS tool used to build community in asynchronous environments), pre-recorded, instructor-narrated lectures, and YouTube videos enhanced their learning. While most did not see English proficiency as a barrier, they offered suggestions that could benefit all students. Participant 54 emphasized the importance of pronunciation in lectures and ensuring content accuracy:

The one thing I really like that [instructors] do is they highlight how important pronunciation is, and with every new organism or word, they slowly pronounce the word and make sure you can hear what it actually is, and sometimes they link like pronunciation websites to help you learn what it actually sounds like. Something that I feel could be worked on is some of the lectures have a lot of typos in them, and I feel like that will be very, very confusing to a non-English speaker because sometimes they use words that fit the lecture but it's not the right word, so I think you'll confuse some people.

Pedagogical approaches mimicking in-person classrooms were also noted as beneficial for learning. For example, Participant 23 shared:

[The instructor] used a platform called VoiceThread to facilitate class discussions, which I found really great and would love to see incorporated into more courses. She also posted her lectures on VoiceThread, which allowed us to asynchronously interject into the lecture to ask questions and for her (and our peers) to respond. I think that was a really neat online way to add that "in-person class" factor to our learning.

Similarly, Participant 57 noted:

I like the VoiceThread. Student[s are] able to ask questions, and you're able to see them and hear them… so that ability of all the student[s] being there, you can pick up on something, you can ask your fellow students, you can ask the professor at the same time. And also, it's like sometimes, when the professor is going to the lecture, you are able to say, "Hey, Professor, can you explain that? I didn't get that."

Another strategy suggested to support learning was offering synchronous sessions within asynchronous online courses. This would allow students to ask the professor questions directly and hear questions from fellow students. Participant 23 said, "For a student whose English isn't that strong, maybe if [students] could synchronously be like, 'Could you slow down or repeat that again?' That might be helpful." Participant 57 added, "If you asked me specifically, I would say having pre-recorded lectures [is] good, but being in [an] online class at the same time, see[ing] the professor right there, see[ing] others, and being able to see what they can ask."

DISCUSSION

A primary objective of this study was to determine if lower English proficiency, as measured by the CELSA, correlated with poorer performance on multiple-choice final examinations for ELL students in science courses taught in academic programs offered asynchronously and online. The research hypothesis posited that ELL students with lower English proficiency, as determined by CELSA scores, would score lower on comprehensive final exams due to language barriers that hinder their ability to demonstrate mastery of the course material. However, statistical analyses found no significant relationship between CELSA and final examination scores for ELL students or for all participants across the six science courses.

The lack of correlation between English language proficiency and exam performance for ELL students contradicts previous studies indicating that language barriers disproportionately hinder ELL performance on standardized content assessments (Abedi et al., 2004; Lakin et al., 2012). However, other researchers have noted mixed results regarding the impact of accommodations for ELLs of varying proficiency levels (Abedi et al., 2000). Several factors may account for the absence of a meaningful correlation between English proficiency, as measured by CELSA, and final exam scores for the ELL sample. A key limitation is the small ELL sample size ($n = 25$), which may have limited statistical power. Additionally, there was a restricted range of proficiency levels within the ELL sample, as most participants scored relatively high on the CELSA assessment ($M = 71.85$, $SD = 3.94$).

Unexpectedly, the analysis revealed weak to moderate correlations between CELSA scores and final examination performance for non-ELL students in three courses. This finding aligns with expectations, as native English speakers with higher proficiency would be expected to score better on content assessments than their non-ELL peers with lower proficiency levels. Notably, 29 of the 66 non-ELL participants (44%) reported being able to speak or understand another language besides English, making them multilingual. Marian and Shook (2012) noted many cognitive benefits of bilingualism, particularly for tasks involving executive functioning skills. Although this was not addressed in the current study, being multilingual may help explain the observed correlations.

Short qualitative interviews were conducted with ELL student participants to provide descriptive insights into the experiences of ELL students in science courses taught in academic programs offered asynchronously and online. Several key themes emerged from the interview analysis. Most students did not consider lower English proficiency a significant barrier to success in their science courses. However, many cited the lack of faculty interaction during high-stakes asynchronous assessments as challenging. Students appreciated technology tools such as narrated video lectures and VoiceThread interactive video forums to reinforce concepts. Overall, students felt supported in the asynchronous online environment through recorded materials and peer interactions. Still, the inability to seek real-time faculty input on questions and assessments was a source of anxiety and frustration. This

aligns with prior research indicating that ELLs tend to prefer frequent interactions with instructors (Andrade, 2014; Harrison & Shi, 2016).

In conclusion, the qualitative interviews provided insights into features that both supported and hindered ELL experiences in science courses taught in academic programs offered asynchronously and online. While students did not perceive general English proficiency as an obstacle, the lack of faculty support during asynchronous assessments emerged as a significant challenge. Access to recorded lectures and interactive video forums was particularly beneficial to their learning experience.

LIMITATIONS

This exploratory study had several limitations that warrant caution in generalizing and interpreting the results. The most significant limitation was the small ELL sample size ($n = 25$), which likely resulted in insufficient statistical power for correlational analyses. A larger, more diverse sample could provide clearer insights into the relationships between language proficiency and performance on asynchronous online assessments for ELLs. In addition, the students were enrolled in asynchronous online courses, which may not be representative of the face-to-face student population.

Our analyses were based on total scores on final examinations rather than performance on individual test questions. It is possible that a correlation between English proficiency and performance on higher-order questions would have been identified if the questions had been analyzed individually.

The ELL participants also represented a restricted range of relatively high proficiency levels. The university's English language admission requirements likely selected higher-proficiency students, limiting variability. Furthermore, the CELSA instrument may not have been sensitive enough to detect nuanced proficiency differences within this population.

Another limitation was the study's inability to control for confounding variables that likely influenced exam performance beyond language barriers. These factors include participants' prior subject-matter expertise, as 70% had previous healthcare professional experience. Other unaccounted variables, such as the number of years spent speaking English, quality of previous education, and socioeconomic background, may also have affected achievement. Although additional data were collected regarding the age of English acquisition and the frequency and comfort of using English versus native language, these factors were beyond the scope of the current study. Future research could explore these aspects using secondary analyses to better understand their influence.

The qualitative interviews were conducted in English by one study member (LS) for whom English is the native language. While common themes were identified by analyzing all transcripts, the participants represented a diverse range of ELL types. Given the small number of individuals interviewed, it would have been difficult to identify convergent and divergent themes among the various ELL categories. Future research that includes a larger and more diverse sample of ELL students may allow for a richer collection of experiences and deeper insights. Lastly, the voluntary nature of participation may have skewed the sample. ELL students who agreed to participate, complete surveys, and be interviewed may not fully represent the perceptions of the broader ELL population.

SIGNIFICANCE AND IMPLICATIONS

Despite the study's limitations, it provides preliminary evidence to guide the enhancement of asynchronous online learning practices for ELLs. While the lack of a correlation between English proficiency and final exam scores contrasts with some existing literature, the qualitative insights regarding assessment barriers align with theories of transactional distance and the need for interactive learning among ELLs (Andrade, 2014; Moore, 1997). The findings suggest that thoughtfully designed asynchronous online courses can successfully support ELLs, but high-stakes assessments in these environments present particular challenges. Incorporating interactive tools like VoiceThread could help bridge these gaps by enabling clarifying discussions around course content and assessments.

Another strategy might be to provide a glossary of terms before each examination, allowing students to familiarize themselves with potentially difficult vocabulary. Though accommodations like glossaries and dictionaries have been shown to benefit students in secondary education (particularly ELLs), their impact on college-level students remains an area for further investigation. As the demand for skilled healthcare professionals continues to rise, this could be an important avenue for future research.

The study also emphasizes the role of emerging technologies in supporting ELL students. AI-powered adaptive learning platforms like Smart Sparrow and DreamBox can customize content delivery according to individual needs. These platforms adjust language complexity, offer personalized feedback, and provide targeted practice in areas where students are struggling (Weltman et al., 2017). They adapt in real time, ensuring that foundational concepts are mastered before advancing to more complex material. Similarly, AI-driven language tools like Grammarly can support ELL students in improving writing and comprehension by offering real-time feedback, explanations, and study assistance—effectively addressing the challenges posed by limited faculty interaction during asynchronous assessments (Wonu et al., 2024).

Furthermore, immersive technologies like augmented and virtual reality offer transformative learning experiences, allowing students to explore virtual labs at their own pace. These tools can also display translations or definitions overlaid onto course materials, enhancing comprehension. Mobile apps, such as Duolingo for language support and Edmodo for collaborative learning, provide flexible, accessible learning options to increase engagement. Tools like MURAL and Padlet facilitate multimodal content delivery by combining text, visuals, and videos to accommodate diverse learning preferences.

The study also underscores the diversity of English proficiency within and outside the ELL classification. ELL students did not uniformly perceive English proficiency as an obstacle, supporting the need for differentiated instruction and accommodations tailored to individual needs and strengths. Another strategy for supporting ELL students could be asking all students for feedback on questions they found confusing after an exam—not only those that were challenging. Instructors could consider removing points for such questions and modifying them for future assessments. In addition, regular feedback from ELL students through anonymous surveys could help instructors gather insights into their experiences with course design, content clarity, assessment formats, and available resources. These surveys could include open-ended questions to capture nuanced suggestions. After major assessments, structured feedback forms could be disseminated, asking ELL students to highlight unclear questions, confusing phrasing, or barriers they faced during preparation or execution. A one-size-fits-all approach may not sufficiently support or engage ELLs, so multiple strategies are likely necessary.

Based on the findings of this study, we have summarized several practical tips for supporting ELL students in an online, asynchronous learning environment:

- Incorporate narrated video lectures and platforms like VoiceThread to reinforce complex concepts through visual and auditory means.
- Offer glossaries of key terms before exams and complex assignments to help ELL students familiarize themselves with challenging vocabulary.
- Use surveys or post-exam feedback forms to identify questions or assignments students found confusing and adapt future assessments based on this feedback to improve clarity and fairness.
- Encourage using language aids, such as online dictionaries or translation tools, during non-communication-related assessments.
- Provide personalized feedback on assignments to help students improve their content knowledge and language skills.
- Pair ELL students with multilingual peers in group assignments to foster collaborative learning and mutual support.
- Use shared documents or breakout rooms to encourage interactive problem-solving.

- Provide transcripts for videos and captions to support comprehension.

Although this preliminary study yielded mixed results, it lays the groundwork for future research aimed at enhancing asynchronous online learning experiences for ELLs. The findings can inform the development of more effective, evidence-based teaching practices to improve the learning outcomes of linguistically diverse students. The COVID-19 pandemic has underscored the need for curricula and assessments that empower ELL students to reach their full academic potential in an asynchronous online setting. Embracing linguistic and cultural diversity creates an inclusive and empowering environment for ELL students. Instructors can validate students' unique perspectives by encouraging them to share how course topics relate to their cultural contexts. For example, discussions on global health issues could include insights from students' home countries, enriching the learning experience.

CONCLUSION

In an increasingly technology-driven educational landscape, equipping ELLs for academic success requires a deep understanding of the barriers and supports that affect their achievement in asynchronous, online achievements. This exploratory mixed-methods study provides preliminary insights into the factors influencing ELL performance in science courses taught in academic programs offered asynchronously and online. While English language proficiency did not directly correlate with final examination scores, qualitative data highlighted perceived challenges related to high-stakes asynchronous assessment formats. Access to recorded lectures and interactive video forums appeared to enhance comprehension, but the inability to ask clarifying questions during exams emerged as a source of frustration and potential inequity.

These findings offer valuable guidance for enriching asynchronous online learning experiences for marginalized ELLs through evidence-based teaching practices tailored to diverse needs. More rigorous research is needed to identify optimal support strategies that maximize achievement in these environments and address persistent equity gaps. However, enhancing asynchronous online platforms to be more socially interactive holds promise for empowering the next generation of diverse scientists and healthcare professionals.

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The authors of this publication declare there are no competing interests.

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APPENDIX A

Intake Form

Impact of Being ELL on Online, Science-based Examination Performance

Thank you for your interest in participating in a research study being led by a team of faculty in the Biomedical Laboratory Sciences Department. Please complete this short (less than 5 minutes) Intake Form and schedule a time to meet with a member of the study team for the first part of the study.

In appreciation of your complete participation, you will receive $30 for Part I of the study, (LBQ/CELSA) and $10 for a subsequent CELSA. If you are asked to participate in an interview, you will receive an additional $25 upon completion of the interview.

You will also receive three (3) extra points to the score of the exam in your course which covers clinical research.

1. First Name
2. Last Name
3. Email address
4. I have previously participated in this study and am interested in participating again by completing the CELSA again.
   Yes
   No

APPENDIX B

Language Based Questionnaire

Q1 INTRODUCTION Thank you for your interest in participating in a research study to examine the relationship between being multilingual and scores on multiple-choice, board-exam like examinations in online science-intensive courses. We are recruiting students who are enrolled in the GW Department of Biomedical Laboratory Sciences' Bachelor's in Medical Laboratory Sciences (MLS), Master's in Laboratory Medicine, and Post Baccalaureate Certificate (PBC) Programs. If you agree to participate, you will be asked to complete a brief Intake Form and then schedule a time to participate in Part 1 of the study, which includes review of the Informed Consent Form and completion of an electronic version of the Language Background Questionnaire (LBQ) and the Combined English Language Skills Assessment (CELSA) during an up to 45-minute long, online video conference with a member of the study team. If you qualify, you may also be asked to participate in a recorded 30-minute interview to explore your experiences in learning and taking exams in an online environment. All data collected will be reported in aggregate form without any identifying information to ensure your confidentiality. In appreciation of your complete participation, you will receive $30 for Part I of the study, (LBQ/CELSA). If you are asked to participate in an interview, you will receive an additional $25 upon completion of the interview. Your participation in the study is completely voluntary and will not impact your relationship with the study team comprised of the co-PIs: Professors Lisa Schwartz, Carol Rentas, Cliff Cymrot, Marcia Firmani, Rohini Ganjoo, and Yousif Barzani. As a student of a BLS Department, your reputation/status or access to the program services or resources will not be affected in any way should you choose not to take part or to withdraw at any time. If you have any questions regarding the study, please contact the Principal Investigator, Professor Lisa Schwartz at (571) 553-0137 or LSchwartz@gwu.edu. This study (IRB# NCR202864) was determined to be research that is exempt from IRB review under DHHS regulatory category 2.

PURPOSE The objective of this study is to examine the relationship between students being multilingual and scores on multiple-choice, board-exam like examinations in online science-intensive courses among a sample of students enrolled in the GW SMHS BLS programs. We wish to explore if examinations, which in traditional, face-to-face classrooms are typically administered in person, at the same time, and with the availability of a faculty member to provide input, when conducted online and not at the same time without faculty support, have an impact on students who are multilingual.

PROCEDURES If you agree to participate, you will be asked to complete a brief Intake Form and then schedule a time to complete an online survey, the Language Background Questionnaire (LBQ), which will take approximately 15 minutes to complete, as well as complete an English-language proficiency test, called the Combined English Language Skills Assessment (CELSA), both of which will be scheduled to be conducted using video conferencing with a co-investigator of the study who is not teaching any of the courses that are part of this study. The CELSA will be given to only one study participant at a time and not recorded. You may also be asked to participate in a recorded 30-minute interview to explore your experiences in learning and taking exams in an online environment. You also give your permission for the principal investigator of the study, who will not be an instructor in the courses, to obtain your score on examinations in your science-intensive courses in your BLS Program via the Grade Center.

RISKS & CONFIDENTIALITY The risk to study participants is minimal. It is possible, although unlikely, that your survey responses may be linked to you. Through the Intake Form, only the principal investigator, Dr. Schwartz, will receive your name and contact information, from which the gift cards will be generated. It is possible that after completing the LBQ, CELSA, or interview you may suspect that you have reduced English language proficiency, and this may result in discomfort or distress. The following steps are being taken to reduce these risks: Your name and email address will be collected by the electronic survey, which will only be available to the principal investigator, who will not be an

instructor in your courses. She will then create a unique identification number for you, which will be used to link your LBQ, CELSA, examination scores, and interview recording and transcript. Once linked and the data collected from the study is combined into a single spreadsheet for analysis, your unique identifier will be removed so that your identity will not be known to the co-investigators, who may be instructors in your courses. The intake form you complete at the beginning of the study to schedule participation in Part I and to receive the gift card will not be linked to your LBQ or CELSA responses and exam scores. At the conclusion of this study, the data collected in the Intake Form, LBQ, CELSA, examination scores, and interviews will be saved for possible future research. However, the data will not be linked to any information that may identify you as a study participant. If you experience discomfort or distress while completing the Intake Form, LBQ, CELSA, and interviews, we encourage you to contact GW Counseling and Psychological Services Office at (202) 994-5300. We also direct you to academic resources available at GW, including the GW Writing Center (writingcenter.gwu.edu) and the Office of Student Services for Health Sciences (smhs.gwu.edu/academics/health-sciences/student-services). Your records for the study may be reviewed by departments of the University responsible for overseeing research safety and compliance.

BENEFITS Taking part in this research will not help you directly. However, your participation may benefit society by helping to inform colleges and universities about whether being multilingual has an impact on student performance on science-intensive examinations conducted in an online environment. With this knowledge colleges and universities may be able to implement strategies to better assist students with reduced English-language proficiency.

COMPENSATION In appreciation of your participation, you will receive $30 for Part I of the study (LBQ/CELSA). If you are asked to participate in an interview, you will receive an additional $25.

QUESTIONS Talk to the research team if you have questions, concerns, complaints, or think you have been harmed. You can contact the Principal Investigator, Dr. Lisa Schwartz, listed on the front of this form. For questions regarding your rights as a participant in human research call the GWU Office of Human Research at 202-994-2715. Your willingness to participate in this research study is implied if you proceed. A copy of this consent form can be emailed to you by request after completion of the survey in case you want to read it again or call someone about the study.

By consenting below, you agree that the above information has been explained to you and you have had the opportunity to ask questions. You understand that you may ask questions about any aspect of this research during the course of the study and in the future.

- I wish to participate and give my consent
- I do not wish participate and do not give my consent

Q2.1 **Please enter the unique identifier provided by the study staff for Part I of the study (LBQ and CELSA).**

_____

Q2.2 What is your gender?

- Male (1)
- Female (2)
- Other (3) _____

Q2.3 How old are you?

_____

Q2.4 Please check your highest education level (or the approximate equivalent to a degree obtained in another country):

- Some College
- Associate's Degree (2 year degree or equivalent)
- Bachelor's Degree (4 year degree or equivalent)
- Some Graduate School
- Masters Level Degree

- Ph.D./Ed.D./M.D./J.D.
- Other: _____

Q2.5 Have you ever had a _____? (Check all applicable.) If yes, please explain (including any corrections):

- vision problem _____
- hearing impairment _____
- language disability _____
- learning disability _____

Q2.6 Have you ever received training and/or worked in the following professions before entering this MLS program?

- Medical Laboratory Technician (or equivalent)
- Medical Doctor (or equivalent)
- Nurse (or equivalent)
- Emergency Medical Technician (or equivalent)
- Other healthcare profession (please indicate the profession in the field below) _____ _____
- I have no previous training or experience in a healthcare profession.

Q2.7 **Can you speak or understand a language other than English?**

- YES
- NO

Skip To: End of Block If Can you speak or understand a language other than English? = NO

Q2.8 If you speak or understand a language other than English, enter those languages below. _____

Q2.9 Please list all the languages you know **in order of dominance**:

- 1 Most dominant language _____
- 2 _____
- 3 _____
- 4 _____
- 5 Least dominant language _____

Q2.10 Please list all the languages you know in order of acquisition:

- 1 First language acquired _____
- 2 _____
- 3 _____
- 4 _____
- 5 Most recent language acquired _____

Q2.11

Country of Origin (birth):_____

Q2.12 **Country of Residence (permanent):**

_____

Q2.13 Do you consider **English** to be your **Native language**?

A native language is defined as **your first language or the language you acquired in early childhood because it was spoken in the family.**

- YES
- NO

Q3.1. If you do NOT consider English to be your native language, which language do you consider to be your Native language?

If you spoke two or more languages in the family environment in early childhood, only write in only ONE language that you used most often with family members.Q3.2 How often do you speak English or your Native Language in the following environments?	Always (1)	Most of the time (2)	About half the time (3)	Sometimes (4)	Never (5)
At **HOME**, I speak **English** (1)	o	o	o	o	o
At **HOME**, I speak my **Native Language** (2)	o	o	o	o	o
At **SCHOOL** (or work), I speak **English** (3)	o	o	o	o	o
At **SCHOOL** (or work), I speak my **Native Language** (4)	o	o	o	o	o
With my **FRIENDS**, I speak **English** (5)	o	o	o	o	o
With my **FRIENDS**, I speak my **Native Language** (6)	o	o	o	o	o
OVERALL, in past five years, I have been speaking **English** (7)	o	o	o	o	o
OVERALL, in past five years, I have been speaking my **Native Language** (8)	o	o	o	o	o

Q3.3. How often do you speak your Native Language with your family and friends?

	Always (1)	Most of the time (2)	About half the time (3)	Sometimes (4)	Never (5)
With my PARENTS, I speak my Native Language (1)	o	o	o	o	o
With my **CHILDREN** (or young family members), I speak my **Native Language** (2)	o	o	o	o	o
With my **SPOUSE** (or boyfriend/girlfriend), I speak my **Native Language** (3)	o	o	o	o	o
With my close **FRIENDS**, I speak my **Native Language** (4)	o	o	o	o	o

Q3.4. Please indicate your agreement with the following statements on specific language abilities

	Strongly agree (1)	Agree (2)	Somewhat agree (3)	Neither agree nor disagree (4)	Somewhat disagree (5)	Disagree (6)	Strongly disagree (7)
It is easy for me to communicate in English on the phone. (1)	o	o	o	o	o	o	o
It is easy for me to communicate in my **Native Language** on the phone. (2)	o	o	o	o	o	o	o

continued on following page

Q3. Continued

	Strongly agree (1)	Agree (2)	Somewhat agree (3)	Neither agree nor disagree (4)	Somewhat disagree (5)	Disagree (6)	Strongly disagree (7)
People compliment me on my ability to pronounce **English**. (3)	o	o	o	o	o	o	o
I pronounce **English** well. (4)	o	o	o	o	o	o	o
I speak **English** with correct grammar. (5)	o	o	o	o	o	o	o
I speak my **Native Language** with correct grammar. (6)	o	o	o	o	o	o	o

Q3.5. Please indicate your opinion with the following statements on language learning

	Strongly agree (1)	Agree (2)	Somewhat agree (3)	Neither agree nor disagree (4)	Somewhat disagree (5)	Disagree (6)	Strongly disagree (7)
I pay attention to how people pronounce words and sounds. (1)	o	o	o	o	o	o	o
It is important to **pronounce English well**. (2)	o	o	o	o	o	o	o
It is important to **pronounce** my **Native Language well**. (3)	o	o	o	o	o	o	o
It is important to speak **English grammatically correct**. (4)	o	o	o	o	o	o	o
It is important to speak my **Native Language grammatically correct**. (5)	o	o	o	o	o	o	o
I enjoy **learning** new words and new ways of saying things in **English**. (6)	o	o	o	o	o	o	o
I enjoy **learning** new words and new ways of saying things in my **Native Language**. (7)	o	o	o	o	o	o	o
I want to **improve my pronunciation** of **English**. (8)	o	o	o	o	o	o	o

continued on following page

Q3. Continued

	Strongly agree (1)	Agree (2)	Somewhat agree (3)	Neither agree nor disagree (4)	Somewhat disagree (5)	Disagree (6)	Strongly disagree (7)
I want to **improve my pronunciation** of my **Native Language**. (9)	o	o	o	o	o	o	o
If it were possible, I would pronounce **English** like people born in the US. (10)	o	o	o	o	o	o	o
It is not important to pronounce **English** well because pronunciation doesn't affect how well you can communicate. (11)	o	o	o	o	o	o	o

Q3.6. Please indicate your agreement with the following statement on speaking English

	Strongly agree (1)	Agree (2)	Somewhat agree (3)	Neither agree nor disagree (4)	Somewhat disagree (5)	Disagree (6)	Strongly disagree (7)
Speaking English well will help me financially. (1)	o	o	o	o	o	o	o
I try to have as many American (native **English**) friends as possible. (2)	o	o	o	o	o	o	o
Americans will respect me more if I speak (grammar, vocabulary) **English** well. (3)	o	o	o	o	o	o	o
Americans will respect me more if I pronounce **English** well (4)	o	o	o	o	o	o	o

Q4.1 **Age at which you first left home country (country of origin):** (If not applicable, please enter NA)

_____

Q4.2 **Age at which you arrived in the US:** (If not applicable, please enter NA)

_____

Q4.3 **Age at which you first felt comfortable speaking English:** (If not applicable, please enter NA)

_____

Q4.4 Please review the categories below and choose the category that best describes you.

- I immigrated to the US as an adult from another country for better economic, political, or social opportunities. (3)
- I arrived in the US as a child or teenager and have learned sufficient English so that I can communicate in both English and my native language. (6)
- I am an international student who is in the US to improve my English, take courses, or obtain a certificate or degree from this US institution. (7)

Q4.5 Please review the statements below and choose the statement that best describes how language may affect your ability to succeed in the MLS courses.

- Being a non-native speaker of English likely **makes it more difficult for me to achieve success in the MLS courses.** (1)
- Being a non-native speaker of English likely **has no effect on my ability to achieve success in the MLS courses.** (2)
- Being a non-native speaker of English likely **makes it easier for me to achieve success in the MLS courses.** (3)

APPENDIX C

CELSA Language Skills Assessment

Sample Questions – ESL Test

Directions for students

Read each sentence carefully. You will see words in a box. There are 4 answers for each question. Only one is correct. Choose the best word to complete the sentence. Fill in the letter of the correct answer.

Here is an example:

a. for two weeks ago
b. since two weeks.
c. for two weeks.
d. for the week before last.

1.
Bob has had an essay assignment. However, Bob

APPENDIX D

Qualitative Interview Questions

For student participants:

1. Please describe your cumulative experience, in terms of years, course content of previous degrees completed, in science-based courses taught in English.
2. If you've been working, how many years have you been working in a science- based field, such as medical laboratory technician, EMT, nursing, phlebotomy, etc.?
3. What strategies do you use to learn material in your science-based MLS courses, including studying for examinations?
4. Do these strategies differ based on the teaching tools used in an online course (e.g., discussion board, videos, recorded lectures, etc.)?
5. What do you see as being the most challenging aspect(s) of taking a science- based course in an online environment?
6. What do you see as being the most helpful aspect(s) of taking a science-based course in an online environment?
7. What are some strategies that instructors can implement to support learning among students with varying degrees of English language proficiency?

Dr. Carol Rentas has over 17 years of experience in clinical laboratory science and more than 18 years in education. She worked as a medical laboratory professional in hospitals nationwide before transitioning to education. Dr. Rentas has taught or currently teaches online courses in laboratory operations, urinalysis and body fluids, clinical chemistry, and immunohematology.

Mr. Ramapoza O'Dwyer is a graduate of the Post-Baccalaureate Pre-Medicine Certificate Program at the George Washington University School of Medicine and Health Sciences. He served as a student ambassador in the Health Resources and Services Administration-funded Health Career Opportunities Program and is now a medical student at Georgetown University's School of Medicine. Mr. O'Dwyer is also a certified medical-surgical registered nurse.

Dr. Rohini Ganjoo is an accomplished educator, researcher, and academic leader with over 12 years of experience in science education. Her accolades include the Graduate Teaching Award from the Northeastern Association of Graduate Schools and the Morton A. Bender Teaching Award from George Washington University. Dr. Ganjoo's expertise encompasses curriculum development, program assessment, and strategic planning, enabling her to guide institutions toward excellence. As a program director, she has shaped educational experiences and contributed to institutional success. Her research focuses on social norms–based interventions, vaccination promotion, and health equity in education.

Dr. Marcia Firmani has been a laboratory sciences educator for over 20 years and is the chair of the Biomedical Laboratory Sciences Department. She has participated in NIH-funded research on microbial pathogenesis and recently completed a five-year Health Careers Opportunity Program grant that created pathways into health professions for students from educationally or economically disadvantaged backgrounds. Her current research focuses on biomedical science education and workforce development. In addition to her work in medical laboratory science programs at several universities, she spent two years as a principal investigator at the National Biodefense Analysis and Countermeasures Center, conducting biothreat characterization research and working in biosafety level 2, 3, and 4 laboratories. Dr. Firmani also directs and teaches undergraduate and graduate courses, including Bacteriology, Molecular Epidemiology, Microbes and Society, and Plagues, Pandemics and Epidemics within the George Washington University School of Medicine and Health Sciences.

Dr. Cliff Cymrot is the program director for Medical Laboratory Sciences at George Washington University and has over 15 years of combined teaching and clinical laboratory experience. In addition to his program director responsibilities, he teaches online and face-to-face courses in Hematology, Bacteriology, Immunohematology, and Biochemistry. He is a member of the Mid-Atlantic chapter of the American Society for Clinical Laboratory Science. He also holds American Society for Clinical Pathology, American Medical Technologists, and American Association of Bioanalysts certifications in medical laboratory science. Dr. Cymrot's research focuses on laboratory science education in higher education, with projects exploring student perceptions of the profession, improving admissions criteria, and the impact of English as a second language on academic performance.

Dr. Yousif Barzani is an educator, researcher, assistant professor, and program director of the Master of Science in Health Sciences in Laboratory Medicine program at George Washington School of Medicine and Health Sciences. With over 10 years of teaching experience, he teaches undergraduate and graduate courses in laboratory medicine. His research interests include student outcomes and professional development, medical education, health disparities, and health equity. Dr. Barzani serves on several George Washington educational and diversity committees, including the Institutional Review Board, the University Integrity and Conduct Council, the Antiracism Guiding Coalition, the Clinical Research Conflicts of Interest Committee, the Health Sciences Curriculum Committee, and the George Washington University School of Medicine and Health Sciences Medical Laboratory Sciences Advisory Board. Additionally, he is a member of the American Society for Clinical Pathology and the American Society for Clinical Laboratory Sciences. As an American Society for Clinical Pathology Career Ambassador, he promotes laboratory science careers within the community. Additionally, Dr. Barzani serves on the Journal of Collaborative Healthcare & Translational Medicine editorial board and is a peer reviewer for the Pathology Laboratory Medicine Board and Certification Review by StatPearls Publishing (2021 edition) and the Laboratory Medicine journal.

Dr. Lisa Schwartz is an education professional with over 25 years of experience in higher education and healthcare, specializing in program and curriculum development, student and faculty development, grant writing, and research. She has held leadership roles, including founding director of the Post-Baccalaureate Premedicine Certificate Program and associate director of the Research Education, Training and Career Development component of the National Institutes of Health–funded Clinical and Translational Science Institute at Children's National, a $20 million collaborative initiative between The George Washington University and Children's National Medical Center. Her research focuses on the career development of health professionals and trainees. Dr. Schwartz received the Jane Engelberg Memorial Fellowship of the National Society of Genetic Counselors for her research on the professional identity of genetic counselors.