
# 5

# Development of an English for Research Purposes Program for STEM Graduate Students

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Research for this chapter was conducted at a national postgraduate research institute focused on science, technology, engineering, and mathematics, with departments of Materials Science, Information Science, and Knowledge Science. The institute has one of the highest percentages of international faculty and students in the country, with 42% of the students and 18% of the faculty being non-Japanese. The majority of international students are from China, with smaller groups from Bangladesh, India, Myanmar, Thailand, Vietnam, and more than a dozen

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other countries. Courses are offered in Japanese and English in alternate eight-week quarters. As the majority of the faculty is Japanese, most research labs operate primarily in that language.

To satisfy graduation requirements, doctoral candidates are required to have between one and three research articles accepted for publication; Japanese students tend to publish in their first language and international students in English. No stipulation regarding the language of the publication is made. Master's students need only complete coursework and a thesis, in either Japanese or English.

Students face no foreign language requirement to matriculate; non-Japanese students are assumed on the basis of application documents and interviews to be able to complete their coursework in English; Japanese students are expected to study in their native language. While there is no restriction regarding language of study, to date no Japanese student has graduated by taking coursework exclusively in English. A growing number of international students now complete their degrees in Japanese, and a small number of Japanese students have written dissertations in English.

## Needs Analysis

English for Specific Purposes (ESP) curriculum design has been the focus of considerable attention for several decades (Basturkmen, 2010; Belcher, 2009; Hutchinson & Waters, 1987; Mackay & Palmer, 1981), and needs-informed curricula have become standard in English programs throughout the world. It is now considered axiomatic that ESP programs are underpinned by a thorough analysis of the needs, wants and lacks of course participants (Allwright, 1982; Flowerdew, 2013; Hutchinson & Waters, 1987; Long, 2005; West, 1994). Robinson (1991) states that ESP courses are generally taught to adults in "homogeneous classes" in terms of the work or specialist studies that the students are involved in, have a specific time in which their objectives have to be achieved, and encompass education, training, and practice, while drawing on language, pedagogy, and the students' specialist areas of interest. She concludes that "ESP is normally goal-directed and that ESP courses develop from

a needs analysis which aims to specify as closely as possible what exactly it is that students have to do through the medium of English" (p. 3). However, despite the body of research literature and the growing number of Japanese universities that offer graduate degrees in English, little has been written on ESP curriculum design in Japan, particularly on ESP curriculum design for STEM programs.

## Institutional Context

Perhaps due to the level of control over curricula typically exercised by university administrators (Aspinall, 2011; McVeigh, 2002, 2006; Poole, 2017; Toh, 2016), much of the existing literature documents the isolated introduction of ESP courses rather than the establishment of broader, integrated ESP curricula (Farooq, 2011; Fellner, 2011; Muller, 2015; Orr, 1998). There has been significant loosening of government control over university curricula since 1994, when the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) allowed universities greater latitude to design their own programs of instruction. However, introduction of new curricula at individual institutions is still overseen by MEXT, and implemented by administrators rather than faculty, frequently inhibiting needed reforms.

As newly recruited faculty are largely unfamiliar with such an institutional perspective on curriculum, the resistance met by the English-language teaching unit to conducting a needs analysis came as a surprise, as it was rooted in factors and politics of which we were largely unfamiliar. Impediments placed by a key program administrator included denial of access to faculty meetings, and hampering the process of obtaining data on needs, wants, and lacks from professors and students. The administrator, a non-English-speaking non-specialist, viewed himself as the sole stakeholder in this process on the basis of having written the grant proposal which funded the program, a fact that did not become known until much later. Consequently, a "guerilla" needs analysis was conducted to obtain information that allowed aims for the program to be set, a curriculum and syllabi to be designed, and materials and learning activities created.

## Data Collection

Target-context related and learning-context related needs analysis surveys (Bocanegra-Valle, 2016; Hutchinson & Waters, 1987) were used to obtain the required information over the academic year prior to implementation of the new curriculum. Data collection methods included documentary analysis, questionnaires, focus-group interviews, online surveys, and subsequent observation of students in the writing lab. We proceeded from Hutchinson and Water's framework for analyzing target needs (1987, pp. 60–61) to answer the following questions:

1. Why is the language needed?
2. What will the content areas be?
3. Who will the learners use the language with?
4. How will the language be used?
5. Where will the language be used?
6. When will the language be used?

Secondary data sources, including course syllabi for content courses, laboratory rosters, and research articles in the university research archive were examined. Course syllabi were examined to determine the language used in the classroom on the assumption that syllabi available solely in English would indicate a greater need for English among the students in those classes. Laboratory rosters were mined for information on the nationality of students in those labs. The university research archives were mined to determine which research labs were publishing most frequently in English, again on the assumption that labs whose members were publishing most frequently would have the greatest need for the courses we were employed to offer.

Primary data were collected from approximately 300 graduate students aged 23–40 with a mixed-methods questionnaire regarding needs, wants, and lacks, plus subjective questions regarding their previous English-language study experience and feelings toward communicating in English. It was initially administered to small groups during classes and later online. The questionnaire was constructed in English and professionally translated into Japanese. Following a small-scale pilot,

minor revisions were made to increase clarity. Six 30-min semi-structured focus-group interviews were conducted by a professional interpreter on campus with approximately 100 graduate students. The notes taken were summarized, and member checks were conducted to verify the accuracy of the summaries.

## Findings of Needs Analysis

An examination of the research archive revealed a marked disparity in the number of documents published in English by labs in Materials Science, Information Science, and Knowledge Science, and that three labs were responsible for 80% of the research output in English during the previous three years. The research articles found in this search were later used to create corpora which enabled us to undertake a granular analysis of the discourse conventions of research articles produced by various faculties and labs.

None of the students who responded to the survey had previously received instruction in technical communication, either in their native language or in English, and the majority of respondents expressed reservations about their ability to undertake academic or specialist tasks in English. None of the non-Japanese students interviewed had previously taken English for Academic Purposes (EAP), ESP, or technical communication courses; most reported that their exposure to English over their undergraduate studies was limited to translation exercises. Table 5.1 shows the activities that students conduct in English according to their degree level, and whether their language was Japanese or not, or whether the primary language used in their lab was Japanese or English.

All non-Japanese speakers ($n = 137$) who participated in a questionnaire survey conducted during the first term of the 2020–2021 academic year stated they "agreed" or "generally agreed" that they were able to use English in the academic or professional/conference settings below. In contrast, Japanese speakers ($n = 156$) stated that they "agreed" or "generally agreed" they were able to read abstracts (76%), conference papers (68%), and journal articles (68%), give lab (65%) or poster (64%) presentations, and write lab reports (59%) or abstracts (62%), revealing

**Table 5.1** Needs analysis results

| Degree | First language | Lab *lingua franca* (mean English proficiency) | Activities conducted in English | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Write abstract | Socialize | Write thesis / dissertation | Read research articles | Discuss studies | Present poster | Present paper | Write research articles |
| MS | JA | JA (basic) | ✔ | | | | | | | |
| | | EN (basic) | ✔ | ✔ | | | | | | |
| | | EN (independent) | ✔ | ✔ | ✔ | ✔ | | | | |
| | Other | EN (basic) | ✔ | ✔ | ✔ | ✔ | | | | |
| | | EN (independent) | ✔ | ✔ | ✔ | ✔ | ✔ | | | |
| PhD | JA | JA (basic) | ✔ | | | ✔ | | | | |
| | | EN (independent) | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| | Other | JA (basic EN user) | ✔ | ✔ | | | | | | |
| | | EN (independent) | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |

*Note* JA (Japanese); EN (English); Basic users (mean TOEIC score <500), Independent users (mean TOEIC score >500)

a disparity of a quarter to one third between the two groups. Unlike the non-Japanese respondents, most Japanese respondents (68%) indicated they had little or no confidence in their ability to write an article of publishable quality in English.

Data mining of the university archives bears this out. The majority of dissertations submitted by Japanese students over the past 15 years were written in their native language, with an English abstract appended in roughly 80% of the papers reviewed in the writing lab. Most English-language dissertations authored by Japanese STEM Ph.D. candidates were from a small number of laboratories, mainly in Materials Science, and all of which publish extensively in English. Five laboratories accounted for well over half of these dissertations.

It would appear from this data that the majority of Japanese STEM Ph.D. candidates' English-language needs still differ little from those of master's students, i.e., reading research articles and writing a research abstract, again highlighting a disparity in English-language needs based not on discipline or specific tasks, but on native language. Many of the comments regarding problems Japanese graduate students experience indicate the fundamental level of difficulty they have speaking and writing English; no Japanese respondents specifically mentioned the role they envisioned English playing in their careers.

Comments by Japanese students indicated concern with using English as a spoken medium of communication, and the difficulties they face communicating in English. Extracts of some of their (translated) responses are given below:

Student 8: "It takes time to translate Japanese into English in my head."

Student 11: "It is very frustrating not to be able to find the words … what I want to say."

Student 55: "I wish I could carry a conversation with tempo."

These students stated a preference for English-language classes focusing on the four skills and vocabulary development. On the other hand, non-Japanese students' concerns generally lay in the use of English for

academic and professional purposes, perhaps reflecting the necessity of using English to complete their degrees, engage in research, and publish their findings.

Small group and individual interviews with non-Japanese Ph.D. candidates revealed that they faced difficulties listening and taking notes during English lectures by Japanese professors, making their questions understood by Japanese professors, understanding their research supervisor clearly during lab meetings and one-on-one meetings, managing their academic reading load, writing and presenting lab reports, comprehending unfamiliar English accents, and preparing manuscripts for publication. Comments received included:

Student 8: "Understanding the research article and writing a research article."

Student 19: "The greatest challenge is listening English from many foreign accents."

Student 42: "Coherence and logic in writing."

These surveys revealed that the primary driver of needs was not specific to the students' field of research, nor the tasks they needed to be able to perform in English, but related to first language: roughly half the Japanese respondents indicated that research writing in English was not necessary, while the non-Japanese respondents universally stated that publishing research in English was important to their academic and career prospects. On the basis of this needs assessment, it became clear that a modular approach to curriculum comprising communication skills, EAP, and English for Research Publication Purposes (ERPP)/technical communication courses was needed.

Japanese master's students expressed limited need to communicate in English, but were interested in courses that facilitated interaction with non-Japanese speaking lab mates. They needed to be able to comprehend research documents in English and perhaps to write a brief abstract of their thesis in English. Japanese master's students stated that they find communicating with international students difficult, while Japanese

Ph.D. candidates said they found communicating in English "troublesome" and reading and writing papers in English both difficult and time-consuming.

Non-Japanese speaking international students in the master's program expressed a greater need for English skills, as they needed to complete their degree, to negotiate the university bureaucracy, to consult with their supervisors, and to interact with other students on campus in English. International Ph.D. candidates needed to use English for written publications and participation in academic conferences, as well as to conduct their affairs on campus and consult with their supervisors.

Based on the results of the questionnaire survey, focus groups and document analysis, the expected target numbers for courses were revised. Table 5.2 shows the expected target market prior to the needs analysis and the actual target market following the needs analysis.

## Curriculum and Course Structure

Our findings showed that the English-proficiency problems identified by our international students were shared by their counterparts at EMI universities abroad (Hamid et al., 2013; Hu et al., 2014). Berman and Cheng (2010) have highlighted universal linguistic challenges faced by NNS graduate students studying in English, while others have identified specific areas of difficulty such as difficulty reading academic texts (Andrade, 2006), understanding lectures (Hellekjær, 2010), comprehending accents (Tange, 2010), and lack of vocabulary (Kırkgöz, 2005).

Given that the Japanese students surveyed expressed concerns with issues fundamental to using English for communication rather than for academic or research purposes, yet faced no requirement that they take English classes, and that the international students were expected to satisfy their degree requirements and write or publish in English, the decision was taken to adapt the existing curriculum to try to satisfy the needs of both groups. We assumed that less proficient students could take non-credit-bearing foundation courses, and then EAP courses, before proceeding to ERPP/Technical Communication courses if necessary. To that end, the following curricular structure was devised, adding

**Table 5.2** Technical communication course preferences

| | Prior to needs analysis | | Following the needs analysis | |
|---|---|---|---|---|
| Course title | Expected Target market (ETM) | Number of students in ETM | Actual target market (ATM) | Number of students in ATM |
| Abstract reading | All | 900 | M1, D1 | 350 |
| Abstract writing | M2, D1, D2, D3 | 750 | M2, D3 | 350 |
| Reading research | M1, M2 | 300 | M1, M2 | 150 |
| Thesis writing | M2 | 150 | M2 en | 60+ |
| Dissertation writing | D3 | 200 | D3 en | 80 + |
| RA writing | D2 | 200 | D2 | 150 |
| Lab communication | M1 | 150 | M1 | 150 |
| Paper presentations | D2 | 200 | D2 | 150 |
| Poster presentations | M2, D1 | 350 | M2, D1 | 250 |
| Seminar discussions | M2, D1 | 350 | M2, D1 en | 80 |

*Note* M: master's degree; D: doctoral degree; numbers 1, 2, 3 represent year of study; en: member of English-speaking laboratory. Thus, M1 is a first-year master's degree student, and D2 is a second-year doctoral degree candidate

the Basic and Intermediate Technical Communication courses to existing introductory English courses and the re-badged Presenting Research and Scientific Discussion courses. The expected course progression for students is given below.

*Spoken Technical Communication Courses*

Interaction Seminar 1: Conversation practice.
Interaction Seminar 2: Conversation practice.
Basic Technical Communication 1: Discussion & Debate.
Intermediate Technical Communication 1: Presenting Research.
Scientific Discussion I: Critical and Logical Thinking.
Scientific Discussion II: Critical and Logical Thinking.

*Written Technical Communication Courses*

Basic Technical Communication 2: Introduction to Academic Writing
Basic Technical Communication 3: Reading Research Articles.
Intermediate Technical Communication 2: Introduction to Writing Research.
Advanced Technical Communication 1: Writing Research Articles.

This progression was seen as the best compromise available given the institutional parameters in place. The goal was to meet the needs of the largest number of students while providing remediation, a comprehensive grounding in the skills students would need to meet the demands of their degree, and courses that would enable students who needed to present and publish to do so.

## Modules and Course Design

The needs analysis indicated that non-Japanese Ph.D. candidates had both the most pressing and widest range of needs for English. Their need to use English for research presentations and publications thus became the aim of the curriculum, and other courses were designed in order to support that aim. Given that other students shared overlapping

but more limited needs, a decision was made to design a curriculum that would accommodate the former group while allowing students with more limited needs to focus on either developing specific competencies, or taking a wider complement of courses that would prepare them for more advanced courses and eventually to use English in academic and professional settings.

Based on existing restraints and the findings of the needs analysis, four modules were established. Each module comprises two or three courses and targets students within a particular TOEIC range as shown in Table 5.2.

1. *Interaction Seminars,* focusing on the development of fundamental communicative competence for students of limited English proficiency, are aimed at improving their ability to interact with other students in their labs in English.

2. *Basic Technical Communication Courses* (EAP) are intended for students who need English to take classes and complete coursework. They introduce students to the writing of descriptive, expository, and deliberative essays, the foundations of logic and critical thinking, and framing and supporting arguments based on evidence. The reading course introduces this group of students to the genre of research articles. While the need to read research in English is universally shared, it was felt that addressing the needs of master's students would be more effective, as we inferred that students on the Ph.D. program would already be familiar with them from previous studies.

3. *Intermediate Technical Communication Courses* are aimed at students planning to pursue a Ph.D. who need to be able to write up and present research. These courses enable students to produce and present research documents that conform in structure and language to authentic documents from their discipline, and to discuss their research in English. While a relatively small number of students surveyed mentioned the need to write research, make conference presentations and present posters, the ability to publish and present

is critical to both academic and professional success and cannot be neglected in any English program aimed at graduate students.

4. *Advanced Technical Communication Courses* are intended for students preparing to publish original research and engage in discussion of their research in international forums. The Writing Short Research Articles course focuses on the production of a manuscript suitable for submission to a conference or journal. Faculty supervisors oversee the conduct of research and recommend a suitable target publication, while English instructors assist students with the analysis of articles from their target publication, the development of an outline, an extended summary based on the same set of questions used on all TC courses, and the completion of a draft manuscript. At each point in the process, from outline and summary to individual sections of the manuscript, drafts and revisions are reviewed by students' faculty supervisors.

Abstract writing, a universal need, is addressed to different depths in the basic, intermediate, and advanced courses. While a number of students mentioned the need to write theses and dissertations, we felt that this was more properly the ken of research supervisors and took the decision not to offer these courses and to return all manuscripts or drafts submitted to the writing lab. There was a strong consensus that we should not advise on work that would be submitted to satisfy graduation requirements. While Ph.D. candidates do have to publish to graduate, and the research in these publications frequently appears in modified form in dissertations, publications are subject to external review and are thus different to the process of submitting and defending a dissertation.

Students on all courses are assessed on a series of tasks that together form a final project for that course. In addition, they are graded on the quality of the assignments they upload to the learning management system (LMS); feedback is visible, and students can query their grades and resubmit assignments to raise them. For final assessment, students on the *Reading Research* course are asked to highlight the answers to the same series of questions used on that course in a model paper within a

specified time. Students on the *Introduction to Writing Research* course produce an outline and detailed summary of their chosen article using appropriate style and tone; students on the *Presenting Research* course submit slides and give a 10-min talk followed by Q&A. Students on the *Writing Research Articles* course produce a draft manuscript that is (theoretically) suitable for submission. The aim here is to help students focus on the level of performance necessary for success in a real-world rather than a classroom setting, and to encourage them to focus on satisfying an audience of their peers rather than simply satisfying the demands of a course or their instructor.

## Links Between and Among Courses

The curriculum was designed so that students could not only master the required competences in a logical order, but that they could build on the content and artifacts created in previous courses. This progression starts from the *Reading Research* course, in which students analyze the structure, organization, composition and construction of the carrier content excerpts. The same approach is later applied to analyzing an authentic journal article chosen from their major field with the aim of achieving a better understanding of the relationship of their various parts, and how they work to create a coherent whole.

Students first skim and scan to find the "answers" to a set of questions about various sections of a research article (RA) using carrier content, and then use these questions to identify corresponding information in a self-selected RA from their own field. The answers to these questions, which together provide an overview of the article, are used as the basis for a summary that they produce for the *Introduction to Writing Research* course. This summary, in turn, becomes the foundation of the presentation that they make in the *Presenting Research* course. A detailed outline of the moves and steps in the organization of the RA undertaken on the *Writing Research* course provides a framework for an original manuscript students draft in the *Writing Research Articles* course.

Students on the *Reading Research*, *Writing Research*, *Presenting Research*, and *Writing Short Research Articles* courses recycle the same "carrier

content" taken from various authentic RAs and chosen using the following criteria:

1. authenticity—adherence to generic conventions of RAs;
2. appropriacy—linguistic conventions, common features;
3. accessibility—low lexical density, topic familiarity;
4. structure/organization—clear evidence of structure/development for that section of an RA;
5. accuracy—free of grammatical and lexical errors and marked usage; and
6. clarity—clear writing style, avoidance of jargon and unnecessary complexity.

Recycling of carrier material throughout courses was seen to offer a number of practical advantages. The most fundamental concepts, skills, and knowledge are presented early, in the *Reading Research* course, which is also the final course in the EAP/Foundation component. It provides the basis for tasks and activities in more advanced courses, allowing students who have completed this course to take more advanced courses and focus on linguistic and rhetorical conventions rather than the structure, organization, and comprehension of research articles. It also enables students to gain a firm grasp of the skill they will most frequently employ and serves as both a culminating course for students who will not need to present or publish and point of entry for students not in need of the Foundation or EAP courses.

Tasks and activities using this carrier content introduce students to linguistic and structural aspects of various sections of research articles and prepare them to undertake an analysis of an authentic RA from their own field. In doing so, they identify ways in which documents from their discipline conform to and differ from "prototypical" Introduction, Method, Results, and Discussion (IMRAD) examples and come to grips with the authentic conventions of research documents in their own field. As students from a wide variety of disciplines are enrolled in these courses, and most master's students are initially unfamiliar with the structure, organization, and language of RAs in English, it seemed appropriate to familiarize them with IMRAD organization of RAs and the

way that this structure works in providing a coherent account of research across disciplines. The concept of moves and sub-moves (Bhatia, 1993; Swales, 1990) is introduced, and lexical bundles indicative of prototypical moves and steps in the development of RAs made explicit. Students in each course are then provided a generic rubric of the move structure of RAs which they use to "deconstruct" an article from their own field to determine its specific organizational and written conventions.

All of the courses blend classroom instruction with preparatory online learning activities (Dobson, 2008; Hockly, 2018; Novak & Patterson, 2000; Tarnopolsky, 2012). The courses are eclectic in approach, drawing on concepts such as flipped classrooms (Berman & Cheng, 2010; Chen Hsieh et al., 2017), and task- and activity-based learning. Students do the majority of their learning outside of the classroom; they typically watch lectures or short "how to" videos online, read assignments, and take notes or complete a set of questions or tasks, and submit these assignments on the LMS before class. Class time is devoted to practical activities intended to develop and practice specific reading, writing, and presentation skills that require students to recall and apply this knowledge. Students thus leave the classroom knowing whether they have been able to apply the knowledge from the homework assignments and have made progress toward completing their assessed projects.

## Pedagogical Implications

In retrospect, data gathered during this needs analysis suggests that the administrator's intransigence was to some extent a face-saving measure; while content courses were offered in English and were theoretically open to all students, there was a de facto separation of students into two distinct groups based on foreign language ability. While foreign students were implicitly required to provide evidence of foreign language proficiency (either Japanese or English) to matriculate, for Japanese students lack of English was not a barrier to entry. While they would need to read English to complete their degree, there was no immediate impetus to develop proficiency in English. Although it was never explicitly stated, the program administrator nonetheless wanted English courses that

catered for the needs of Japanese students, not foreign students, who were assumed to be competent to undertake coursework, present, and publish, presumably on the basis of their having been granted admission.

Perhaps more to the point, the administrator apparently realized that a needs analysis would reveal that Japanese students, who were the intended beneficiaries of the program, were not required to use English to complete their degree. This would have left the administrator overseeing a program conducted by a foreign faculty for foreign students, a situation which, as a non-specialist and a non-English speaker, could potentially have resulted in a loss of power, and thus a loss of face. This assertion of administrative prerogative at Japanese institutions (McVeigh, 2002, 2006; Toh, 2016), where administrators, not faculty, typically make decisions regarding curricula, is not uncommon. Although it was never explicitly stated that the faculty was not to conduct a needs analysis, based on email communications and comments made at official meetings, it was clear that the program administrator was not favorably disposed to our collecting data via official channels. While the upside of such "administrative prerogative" at Japanese universities is that faculty are often able to make decisions regarding pedagogy largely free from administrative interference, when questions arise as to who properly exerts control over certain aspects of a program, it almost by default becomes the province of the administration.

While the program has thus far successfully enabled many international students to publish and present, it has been less successful with Japanese students due in large part to university policies that allow Japanese students to matriculate without English-language proficiency, and to graduate without having developed sufficient facility to participate in international academic forums in their disciplines. This is particularly problematic given the decreasing number of English-language publications by Japanese authors (Phillips, 2017). In addition, as the competition for research funding becomes keener among Japanese scholars, pressure to collaborate with researchers overseas or compete with them for funds increases (Nakano, 2017). Another related issue is that this lack of foreign language facility prevents Japanese universities and research institutes from attracting foreign scholars and researchers,

and their graduates from engaging with counterparts at universities overseas.

The remaining challenge is to prepare more Japanese students to enroll in the intermediate and advanced technical communication courses and to assist them in getting their research published in English so that they can contribute to the international dialogue in their areas of research. A proposal made to a new administration in mid-2020 by this faculty for a pilot program aimed at increasing the number of Scopus-indexed[1] publications by Japanese Ph.D. candidates has thus far generated little interest. The proposed project would have seen a small group of students enroll in technical communication courses while taking coursework in both Japanese and English, and meeting with English-speaking teaching assistants from their home laboratories for course preparation and review. The proposal was predicated on the voluntary participation of Japanese professors and graduate students in labs currently publishing in English in which Japanese students were struggling to produce successful manuscripts. We hoped eventually to expand this program to other labs and eventually to master's students planning to continue to the Ph.D. level, who would have theoretically taken the full range of EAP, ESP, and ERPP courses offered. We can only interpret this decision as a reflection of the bipart-lingual approach that the university has adopted thus far.

## Note

1 Scopus is an abstract and citation database operated by Elsevier Science. It combines a curated abstract and citation database with enriched data and linked scholarly literature across a variety of peer-reviewed journals in life sciences, social sciences, physical sciences, and health sciences. https://www.elsevier.com/solutions/scopus.

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