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A pedagogical strategy addressing an unmet need: Making the biology of aging an accessible part of interdisciplinary gerontology education

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ABSTRACT

In an age of specialization, obstacles to interdisciplinary training and integrated intellectual growth are expected. One such obstacle to graduate-level training in gerontology is the challenge of making the biology of aging accessible to nonbiologists. In this article, the authors' aim is to share 15 years of experience developing a pedagogical strategy that situates the biology of aging as an accessible part of interdisciplinary gerontology education for nonbiologists and biologists alike. The approach hinges on a four-pronged learning opportunity—four course offerings—that places high priority on exactitude with language and sees development of an attitude of precision with language as essential to intellectual growth. By inspiring students to master language in the key of *B—Biology of Aging*—we unleash a versatile method for developing cross-disciplinary discoverers prepared for a lifetime of seeing and reporting.

KEYWORDS

biogerontology; language; interdisciplinary training; graduate education

Introduction

Leaders in gerontological education recognize there are many barriers to effective interdisciplinary training. The payoff for overcoming these barriers is in discovering an improved framework for promoting intellectual growth, which serves as a strong motivation for pedagogical innovation. In many institutions, one of the obstacles to building such a framework is the difficulty in making the biology of aging accessible to nonbiologists. Recognizing the considerable upside of exposing nonbiologists to the tenets of biogerontological thought, we report our 15-year experience at Purdue University in developing an educational opportunity for gerontology graduate students in pursuit of cross-disciplinary excellence.

Our pedagogical approach hinges on a four-pronged learning opportunity—four course offerings—that places high priority on developing exactitude with language and sees development of an attitude of precision with language (rather than focusing solely on knowledge content) as essential for scholars-in-training seeking to become conversant in the ideas of biogerontology (Figure 1). A gateway course, *The Biology of Aging*, serves as

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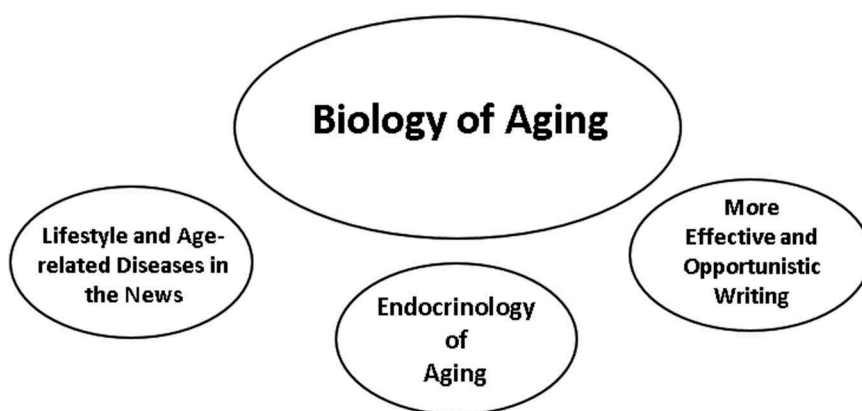


Figure 1. A four-pronged pedagogical strategy. Four course offerings are aligned to situate the biology of aging as an accessible part of interdisciplinary gerontology education. A highly approachable gateway course—Biology of Aging—and three other elective courses reinforce a learning framework that places high premium on cultivating an attitude of language precision.

the initial point of contact with students. At our institution, The Biology of Aging course was developed as a requirement for students in pursuit of the dual-title PhD in gerontology. The three other courses—Lifestyle and Age-Related Diseases in the News, Endocrinology of Aging, More Effective and Opportunistic Writing—were subsequently developed to reinforce the language-driven learning framework established in the gateway course. The vast majority (80%) of participating students are PhD candidates, the remainder of students are MS candidates (15%) and upper-level undergraduates with permission of the instructor (5%). Students who are PhD candidates represent a diverse array of disciplines within the biomedical and psychosocial sciences, including anthropology, kinesiology/exercise science, human development and family studies, psychology, pharmacy, pathology, hearing and speech sciences, comparative medicine, epidemiology, nutrition, and sociology. Approximately one third of the 80 students who have taken The Biology of Aging course have gone on to complete one or more of the satellite courses, based upon student interests and research commitments, and course availability.

Reflecting upon what the four course offerings have in common, one can find overarching themes. First, each course is subject matter-centered, not student-centered, not teacher-centered. Teacher and students have a deep reverence for the subject matter—they want to penetrate it. Second, these courses see science as a process, not a thing. These classroom experiences represent gerontology as a field in flux that calls for close attention. The courses treat science not as a collection of facts, but as a method of inquiry—a *method of inquiry limited by language* (Waters, 2017a). As discoverers, it is natural to think that our focus is on trying to make sense of the world. Yet, as discoverers we are charged with trying to *make sense of a world of words*—the words, the categories that stand between us and Nature, or health, or disease. Undergirded by these foundational principles, this collection of courses challenges students to see as their own responsibility the process of developing a method of inquiry that favors a fluent capacity to reshape beliefs, and a readiness to act upon new (yet always incomplete) information.

Because we see curriculum as that which contributes to the total learning experience, not merely as a syllabus or course of study, these ideas intended to stimulate teaching and learning could be termed a curricular strategy. Instead, we present these ideas as a pedagogical approach because our aim is not to impose limits by emphasizing a particular sequence of coursework, by delegating courses as required versus elective, or by stipulating how this collection of courses relates to a curriculum in aggregate. Rather, in this article, our attempt is to describe the elements of an instructional framework intended to *enlarge possibilities*—triggering new pedagogical possibilities that teachers can incorporate into their own distinctive educational setting.

The biology of aging

The Biology of Aging (3 credit hours, class size: 6–10) introduces students to the questions that biogerontologists wonder about. A priority is placed on building familiarity with a new lexicon—the intimidating new language that runs the gamut from antagonistic pleiotropy to telomerase. A major aim is to develop each student’s ability to interpret key scientific papers.

Ten one-hour lectures introduce language and concepts, with the goal of preparing students for three discussion sessions that serve as opportunities to transform their own thinking. For each discussion session, the instructor selects 12 scientific papers that are read by each student prior to class. During these 4-hour discussion sessions, each student volunteers to lead the discussion of a particular paper. The scientific papers are selected to expose students to a broad array of investigations, ranging from studies using cell culture, worms, flies, mice, dogs, as well as human observational studies and interventional trials.

In some instances, papers are intentionally selected to create tension. For example, a rodent study is selected demonstrating that removal of visceral fat (but not subcutaneous fat) can significantly improve markers of metabolic disease, such as insulin sensitivity (Gabriely et al., 2002). Then, students read a study that tests the hypothesis that the removal of fat by liposuction will significantly improve metabolic markers in women (Klein et al., 2004). The work in women, published in the *New England Journal of Medicine*, shows no beneficial effect of fat removal. Students gain an important perspective: All fat is not created equal. They come to see the failed liposuction study as an expected result—the result of *naïve substitution*, believing visceral fat and subcutaneous fat are equally villainous when it comes to provoking metabolic havoc. *Naïve substitution is the product of language laxity*—leading to unsophisticated, even misleading categories (Waters, 2017a). Students rapidly embrace this notion of naïve substitution as a valuable tool, a lens through which the design and outcome of other studies can be interpreted. As students are exposed to additional examples of investigations that oversimplify heterogeneity, they come to see the quality of their method of inquiry hinges upon a more nuanced category usage. Figure 2 illustrates a desired evolution of category usage. The aforementioned liposuction study was not a study of the effect of *body fat*. It was a study of the effect of *subcutaneous fat*. Precise language shapes precise thinking, enabling scholars in training to sharpen their research method. The payoff for this kind of approach is that a teacher can tackle biology, not by intimidating students with its crippling complexity, but rather by emphasizing the need to develop an attitude of precision with language that enables ideas to be formulated and expressed with sufficient particularity.

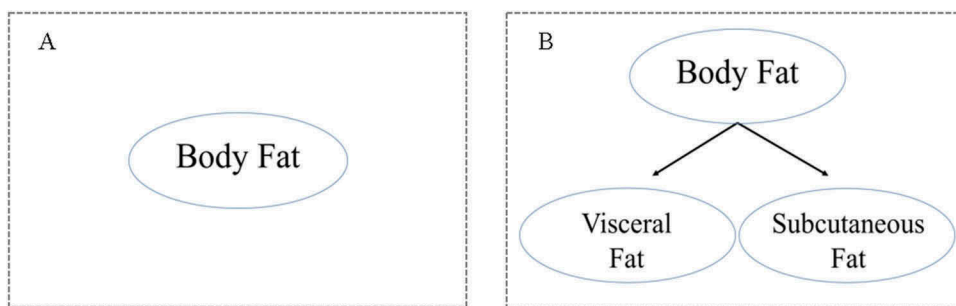


Figure 2. On category usage. An evolution of more nuanced category usage (moving from Figure 2A to 2B) enables ideas surrounding the metabolic impact of body fat (2A) to become advantageously modified to consider consequences with a higher degree of particularity (2B).

Each 4-hour discussion session ends with an intellectually satisfying crescendo—a filling of the blackboard with a concept map, referred to as “Blackboard Magic.” This concept map, conceived by students and recorded by the instructor, captures the new language, the new relations, and the evolution of thinking based upon the day’s work. The students come to see this effort as an essential benchmarking of their individual and collective progress. They gain a critical sense of *ownership*—an owning of those ideas that have bubbled up on the blackboard, those deemed deserving of today’s chalkboard synthesis, and worthy of further introspection.

Students are evaluated based upon their participation in the discussion sessions and their performance on an oral final exam. The 2-hour oral final examination includes questions that assess a student’s command of knowledge content but places premium on the synthesis of ideas, so that the examination becomes an opportunity for discovery. Students engage in 2 hours of written exercises immediately prior to oral examination by the instructor. As part of this written exercise, students are presented sheets of paper containing each of the summaries of “Blackboard Magic” from the three discussions. Students are challenged to consider these images as maps for charting their own personal evolution during the course: early concepts (Discussion 1), middle concepts (Discussion 2), and late concepts (Discussion 3). Students are instructed to write a brief description of the extent to which they believe their view of a particular concept’s value or meaning changed from early to middle to late. For concepts that appeared only once, students are asked to give a possible explanation for their limited appearance.

The course’s capacity to enlarge student understanding might best be illustrated by an example from one student’s final exam. A nonbiology graduate student (PhD candidate in sociology with no biology coursework since high school) wrote about his evolution of thinking regarding two concepts—the role of gene–environment–chance as determinants of health, and the extent to which observed clinical signs reflect insult versus response to insult. The student begins:

On *gene–environment–chance*—“At early stage, I see the importance of chance (stochasticity) for the first time. At middle stage, I see that environment and chance contribute to different pathways of longevity. At late stage, I see the importance of conducting experiments that emphasize elements of chance.”

In our estimation, this student shows an impressive degree of intellectual growth, progressing from a lack of awareness that stochastic events impact longevity, to an appreciation that stochastic events, such as age-associated accumulation of DNA damage, can impact insulin-like growth factor (IGF) levels and the somatotrophic axis (Garinis et al., 2009), one of the widely recognized regulators of longevity across species. The student's thinking continues:

On insult versus response to insult—"At early stage, the ability to respond to insult seems to be more important. At middle stage, symptoms as a form of response to insult may be adaptive. At late stage, I see challenge as a tool to expose hidden heterogeneity."

Again, this student shows considerable growth in his perspective, beginning with a new appreciation for the potential importance of interventions that could modify how an organism responds to insult, rather than simply focusing on modulating exposure to insults as the prime method for health promotion. His thinking then matures to considering that not all symptoms are to be considered "bad," because these responses are in some instances *adaptive* (i.e., beneficial to the organism), such as the age-associated drop in circulating IGFs in humans, which may benefit older adults by decreasing the stimulation of emerging breast cancer or colon cancer cells that often express IGF receptors on their surface (Yu & Rohan, 2000). He completes the course with an appreciation that investigators can gain greatly by using *challenge* (e.g., treadmill test to assess cardiovascular disease risk) to expose differences within a study population, instead of making basal measurements (e.g., resting electrocardiogram), which often fails to achieve risk stratification. He has taken possession of a vital idea that has broad implications for human health: *Environmental exposures expose hidden heterogeneity*. We see this as testimony to the personal growth achievable by a non-biologist during a single semester.

To summarize, the goal of this gateway course is to draw students into a genuine dialogue about the biology of aging. Students form their own abstractions—a set of first impressions by reading a collection of scientific papers selected by the instructor. Intense discussion periods enable students to assess their own process of distilling information and developing impressions and then commit themselves to refining their method of meaning-making.¹

Endocrinology of aging

The motivation for the design of this course was provoked by the work of I. A. Richards, the literary critic who dedicated his life to careful study of the ambiguity of language and the art of close reading. In fact, Richards studied ambiguity so extensively that he coined a new, less derogatory term to describe his prized subject of study: the "resourcefulness" of words (Richards, 1942). In his book *Speculative Instruments* (1955), Richards framed the impact that the ambiguity of language can exert upon teaching and learning, "I don't know a subject in which study of the resourcefulness (ambiguity) of its key terms doesn't amount to the subject, properly studied, itself" (p. 76). The Endocrinology of Aging (2 credit hours, class size: 4), a graduate-level course on hormones and the aging process, was developed to test Richards' radical idea. Instead of placing emphasis on the acquisition of facts within the subject matter of endocrinology, the students and instructor are focused on the language used in that discipline. Particular attention is directed to words whose meaning might not be immediately obvious to a

person approaching the field of endocrinology for the first time. For example, students work to understand in which ways the terms *heterogeneity*, *menopause* (natural vs. surgical), *windows/critical period*, and *pleiotropy* are used by endocrinologists and other biomedical professionals.

Four students who have already taken the Biology of Aging course are enrolled to explore more deeply the field of endocrinology. Each student is responsible for driving one of four domains within endocrinology, which are run in parallel. The domains, selected based on student interest and their importance to the endocrinology of aging, are: (1) fat as an endocrine organ; (2) stress and the hypothalamic-pituitary-adrenal (HPA) axis; (3) ovaries and the hypothalamic-pituitary-gonadal (HPG) axis; and (4) growth hormone/insulin-like growth factor (IGF) axis (somatotrophic axis). After students and instructor complete a 5-week review of the scientific literature, five key peer-reviewed research papers are selected from each domain. These papers serve as the subject matter for five 3-hour discussions in which each student presents a paper from his or her domain. As a result, students and instructor witness a progressive, step-wise growth of understanding within each endocrine domain (Figure 3).

But it is the fruits that come from across-domain integration during each session that present the most unexpected and rewarding learning opportunities. For example, the manuscript selected for Discussion 3 in the ovary domain explores the impact of surgical ovary removal on IGF levels in women. From Discussion 1 and 2 in the IGF domain, students are aware of the relationship between low somatotrophic tone (i.e., low IGF action) and longevity promotion. As a result, students are eager and ready to take keen notice of the direction of change in somatotrophic tone that is triggered by tampering with ovaries (arrows from ovary₃ to IGF₃ in Figure 3). In each student's mind, endocrinology is no longer the detailed study of a particular hormone in isolation. Instead, understanding endocrinology calls for cross-domain, *whole-organism thinking* (Waters, 2013).

Students are evaluated based upon their participation in discussions and an oral final examination. The oral final exam explores the relations within a collection of 50 terms used in the field of endocrinology that students have constructed during class discussions. Students are asked to examine these terms closely, to create their own personal catalogue that reflects how they feel about the language used in endocrinology. During the final exam, students are asked to speak about these words as they relate to their own system of categories that include: (1) most unexpected, (2) instant incorporation into my vocabulary, (3) instant incorporation into my actions, (4) most agile across domains within endocrinology, and (5) most transcendent beyond endocrinology to other areas of gerontological inquiry.

Overall, the outcome of this premium-placed-on-language approach to scientific learning has been quite gratifying. In exit interviews, students reported that they enjoyed an extraordinary comfort level with the subject matter. The endocrinology of aging was no longer an opaque entity. Instead, students felt they had achieved a strong sense of accessibility. The course came to be known as “Endo-Comm,” as it proved to be a productive collision between endocrinology and communication. Reinforced in the students' minds was the notion of *language as gateway to tackling and understanding new scientific information*. Not just for effective communication with others, but for becoming more effective in “talking to themselves”—shaping and reshaping the ideas and linkages inside their heads.

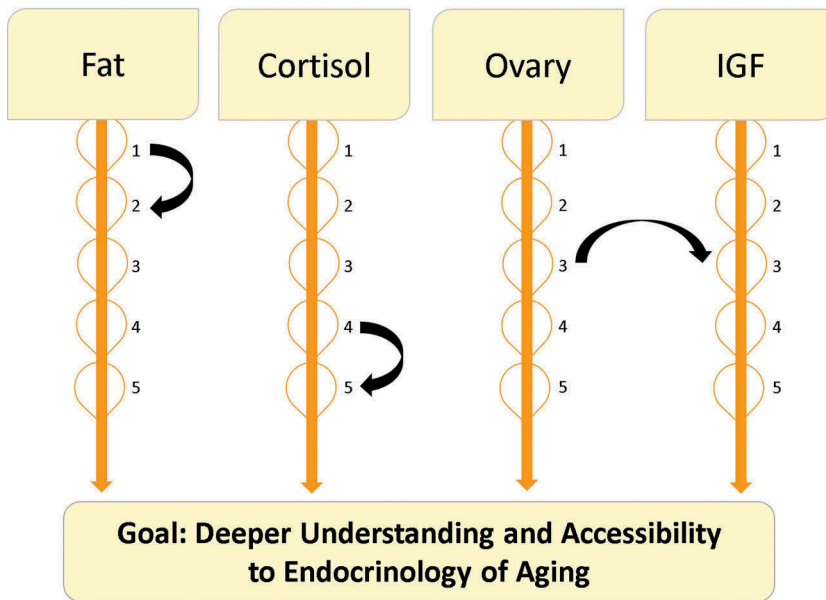


Figure 3. Endocrinology of aging. In this course, each of four domains are explored in parallel using a succession of five discussions. Straight arrows, which flow from top to bottom, represent progression within each domain; each numbered node represents one of the Discussion Sessions 1 through 5. Student understanding within a particular domain is progressively enlarged by successive discussions, for example from fat₁ to fat₂ or from cortisol₄ to cortisol₅. In addition, each discussion provides opportunity for integrated, cross-domain intellectual growth, depicted by curved arrow from ovary₃ to IGF₃ (see text). The goal is to move students toward securing a deeper sense of understanding and accessibility to the endocrinology of aging.

Note. IGF = Insulin-like growth factor.

Lifestyle and age-related diseases in the news

When it comes to the influence of lifestyle on age-related diseases, the public is not hearing the real story. The process of communicating science to the public is broken—and someone needs to fix it. This somber assessment provides the backdrop and rationale for a graduate level course called *Lifestyle and Age-Related Diseases in the News* (2 credit hours, class size: 8–16). The purpose of this course was: (1) to explore further the extent to which the public is misled by media reports of health-related research achievements; and (2) to gain a deeper understanding of the extent to which different factions—scientists, journalists, editors, and the public—create the problem and hopefully can contribute to a solution. In this course, each student is afforded the opportunity to develop further their skills in interpreting clinical research studies from both the academic and public perspective, and to experience first-hand the essentiality of using precise language to communicate scientific messages. To accomplish these goals, each student sequentially plays three roles (Figure 4):

Playing the role of the health-seeking public—Each student chooses a press release approved by the instructor that has appeared within the last 6 months. The student then returns to the original scientific report that appeared in a medical or scientific journal and assigns the press

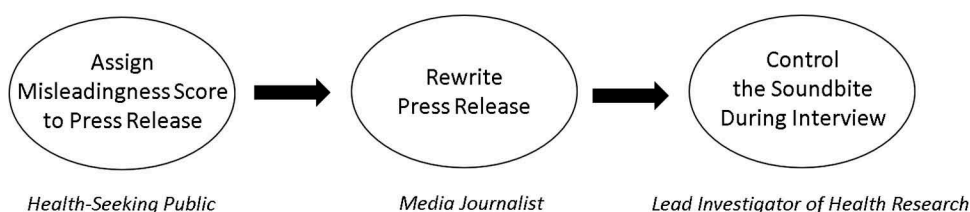


Figure 4. Lifestyle and age-related diseases in the news. In this course, each student sequentially plays three roles—health-seeking public, media journalist, and lead investigator—to explore the essentiality of language precision in the communication of health-related research.

release a *misleadingness score* (0–5 scale) based on careful comparison of the press release with the original scientific article. During classroom sessions, each student leads a discussion pairing the press release with the scientific article, focusing on the particular ways in which the press release leaves the actual work vulnerable to misinterpretation.

Playing the role of the media journalist (person who writes the press release about the published research)—Next, each student is required to write her own improved version of the press release that remedies the shortcomings of the press release that had been released to the public. Students get to experience first-hand the challenge of expressing a complex story succinctly—in people-friendly prose, free of scientific jargon. During classroom sessions, each student presents her “improved” press release for scrutiny by her classmates. As the student describes in detail her revision process, the class engages in an energetic debate about the motivation for and effectiveness of each editorial move.

Playing the role of the lead investigator of the original scientific article—Finally, each student plays the role of the senior author of the scientific manuscript and is “interviewed” by her fellow classmates posing as media journalists. While answering questions pertaining to the design, execution, and interpretation of the original research in question, the “senior author” must exercise great discipline in *controlling the soundbite*—directing the interviewers’ attention to the singular take-home message that the media journalists will ultimately quote in the news release they will spring on the public.

Students are evaluated based upon their classroom participation—executing their role as the public, media journalist, and lead investigator. In an oral final examination, students are asked to evaluate the potential misleadingness of new press releases selected by the instructor. Provoked by the instructor, students are challenged during the oral final exam to think more deeply about who will fix the health news miscommunication problem. Will it be the scientists, the media, or the public who will save the day? Their performance is evaluated based upon their ability to articulate a stance in an organized, compelling manner.

On one level, the course may be seen as a concerted effort to find the “good things” that will enhance health. On a deeper level, the course is *an exercise in language precision*. A broad array of lifestyle-outcome dyads are explored, which range from the association between chocolate consumption and risk of cardiovascular disease; how occupation relates to risk of developing dementia; exercise and subsequent loss of mobility; obesity and prostate cancer outcome. Students emerge with a strong appreciation for how often news about age-related disease conditions is reported to the public out-of-context. “Context determines meaning” becomes a guiding principle for students as they commit themselves to becoming more careful consumers of health news. And perhaps more importantly, as

tomorrow's scholars in gerontology and geriatrics, they commit themselves to becoming part of a solution to the problem. For example, instead of publishing their own research findings in manuscripts containing opaque, jargon-filled abstracts, students set their sight on writing manuscripts with lay-friendly abstracts, so that media journalists can borrow directly ("steal") from the manuscript a polished summary that has been intentionally crafted to be passed on to the public in context.

More effective and opportunistic writing

The premise for this course is that clear writing is clear thinking, clear thinking is clear writing. Moreover, effective writing is too vital a part of a student's intellectual development to leave solely in the hands of the English department. The goal of More Effective and Opportunistic Writing (2 credit hours, class size: 3) is to cultivate an attitude of precision with language. Students grow their writing abilities *through immersion, rather than instruction*. Over the course of eight, 4-hour classroom sessions, the instructor provokes students to consider a collection of "good writing" principles. The interactions are not intended to "sell" students on the virtue of particular principles but rather challenge them to consider: (1) which principles already resonate with them and already shape their own writing; (2) which principles seem foreign and fruitless; and (3) which foreign principles possess a "fruitfulness" that has the potential to transform the way they think about writing.

Throughout the course, students surround themselves with good writers, good thinkers through iterative sampling of a collection of essays and book chapters bundled by the instructor as "41 Acts of Writing." These writings come from philosophers and mathematicians, poets and psychoanalysts. They include such works as "The Perfectibility of the Intellect" by Jerome Bruner (1971), "The Nature of Creativity" by Rollo May (1975), "The Poet's Job Description" by poet-laureate Ted Kooser (2005), and "Language Education in a Knowledge Context" by Neil Postman (1979) who states, "Every teacher a history teacher; every teacher a language educator." Prior to each classroom session, students are assigned to read three of the selected acts of writing. Students come to class excited to discuss in considerable detail what aspects of writing (and meaning) stimulated them most. Building upon these student encounters with superior acts of writing, the instructor creates in-class exercises that serve as provocations to stimulate student writing. For example, the instructor distributes a statement introducing a new idea, *neologism*—the process of formulating new words. In response to this provocation, one student wrote:

"Your neologism is a sign of ownership. It is the prize that comes from a deep caring about the particular—about you in your particular circumstances. It is the logical product of training yourself in unique ways, the benefit of an incredibly unique collision of experiences. Neologism is a celebration of Self, of attempting to articulate the relationship between Self and Other."

Clearly, this student has demonstrated a readiness to view this provocative new idea, neologism, as a potentially valuable tool that he can seamlessly incorporate into his meaning-making process. The student provides a thoughtful, spontaneous expression that represents clear thinking, clear writing.

During the semester, students engage in a writing project on a subject matter that interests them, usually related to their own research. The project asks for a clear statement

of the problem, the research question, and the expected result. In addition, the student is asked to describe, “What is the old script that would likely prevent others from seeing or accepting your new idea?” The student must clearly articulate what is the old script—the customary ways of seeing that folks in her discipline are trapped in. But the exercise is not finished. The student is called upon to generate a second creative idea: The new lens. The student is asked to describe, “What are the new data that are needed so that the second idea can create the lens through which others will see and embrace the shiny, new first idea?” One of us (Waters & Waters, 2011) has coined this exercise “Schank’s Battle Tactics”—the need for two great ideas to advance one, articulated by Roger Schank in his book *The Creative Attitude* (1988). An in-depth exploration of students’ relationship with their writing project, focusing on the evolution of their thinking about the subject matter and evolution of their method, is the focus of the oral final examination.

As students move through the course, their relationship with language changes. Change is apparent in each student’s enlarged capacity for producing clear writings, and their passion for using and responding to language in new and unexpected ways. Students show *a remarkable transformation in the way they read*—shifting from a reading style that is linear and focused on content, to *reading for provocation*, actively seeking the stylistic turns that effective writers use to create memorable phrases and sentences (Waters, 2012). The course does not pretend to offer a step-by-step, cookbook method of achieving effective writing. Instead, it achieves this goal by an indirect method—surrounding students with great writing and challenging them to see their changing relationship with language as an essential maturation: *The way we choose to use language is the way we choose to live.*

Indicators of effectiveness, prospects for replication

Up to this point, this article has sketched out an innovative pedagogical approach that we have used to provide students with a rich set of encounters intended to make the biology of aging accessible to students across many disciplines. Rather than requiring the reader to rely upon bald assertions of the “success” of our strategy or rest upon unexamined assumptions regarding the ease of replication at other institutions, we will address here the issues of effectiveness and replicability. Our remarks are intended to provide the interested reader with a deeper sense of what this pedagogical approach may offer in terms of potential payoffs, as well as probing potential obstacles to implementation.

Indicators of the effectiveness of our strategy can be subdivided into two categories: (1) near-term gain for graduate students; and (2) long-term gain after graduation. Several notable examples of near-term gain are deserving of comment. Of sizeable significance, students experience their first encounter with the biology of aging *in a context of whole organism aging*. This promptly and profoundly shapes how students think about the aging process. For example, PhD candidates in hearing science are enabled to navigate new ideas related to the impact of systemic disease on age-associated hearing loss. Students celebrate their release from specialized, siloed thought in favor of whole organism thinking (Waters, 2013). The hearing science student who is provoked to think “outside the ear” sees this educational experience as an act of “silo-bashing”—a necessary part of their maturation to becoming a multiangled discoverer. PhD candidates in sociology—most of which have not taken a biology course since high school—emerge from these educational encounters less

intimidated by biological complexity. They are open to taking additional coursework in the biomedical sciences and, in some instances, find themselves expanding their sociological research to include biological measures, such as salivary cortisol or telomere length. Importantly, students see that it is their enlarged relationship with language, not simply the acquisition of knowledge content, which is key to opening the doors to this transformation.

That the reshaping of students hinges upon their newly acquired attitude toward language is manifested by their confidence in approaching complex ideas outside of their major discipline. Their familiarity with the lexicon of biogerontology, together with their newly developed ability to actively interrogate acts of writing, renders the contents of scientific journals ranging from *The Journals of Gerontology: Biological Sciences and Medical Sciences* to the *Proceedings of the National Academies of Sciences* as no longer strange or inaccessible. Students feel competent in recognizing themes and embrace the challenge of examining the latest scientific manuscripts for the extent to which they reinforce or refute prevailing ideas. Students in disciplines outside the life sciences report they have experienced “a crossing over”—a new confidence in reading and writing about biology.

More broadly, students show personal growth in their usage of language. An increased particularity for formulating best descriptions (e.g., the term *body fat* superseded by the distinction between *visceral fat* and *subcutaneous fat* depicted in Figure 2), is evident in their writings, including their thesis preparation. This maturation in language usage, which is particularly notable in those students who engage in one or more of the three elective course offerings that build upon the gateway Biology of Aging course, is also manifest as an advance in the clarity of their thinking and their willingness to tackle challenging ideas. The staying power of such transformation is strong, expressed so clearly by one student, “The more you care about language the better equipped you are to describe the world in different ways.”

Although these indicators of apparent near-term gain are encouraging, the most impressive measures of effectiveness are those that suggest long-term gain. Perhaps the strongest signal of effectiveness is the observation that those graduates who become faculty incorporate this pedagogical strategy into the courses that they design and teach. For example, a young faculty designing a Sociology of Aging course *begins the classroom encounter with an introduction to the biology of aging*. On the surface, this decision might seem ill conceived, even eccentric. But, in this case, the teacher finds value in reinforcing in the minds of his undergraduate sociology students the idea that scholars across disciplines are confronting the puzzle of aging from many different angles of vision. Societies are complex systems. And sociologists who have experienced these pedagogical offerings in the biology of aging have been exposed to a multisystems approach that serves as a model to introduce, in turn, to their students the challenges of studying complex systems.

Inevitably, the way we have been taught impacts the way we will teach. Not unexpectedly, then, the pedagogical style of those graduates who become faculty frequently places premium on provoking their students to see how language affects not just their oral and written communication, but also their thinking. Their teaching style demonstrates a keen awareness of how the selection of categories by the instructor profoundly affects the accessibility of complex ideas. For example, are centenarians best understood as homogeneously “exceptional” or better categorized as survivors,

delayers, or escapers based upon their lifetime morbidity profiles? (Evert, Lawler, Bogan, & Perls, 2003). Their teaching philosophy is grounded in the wisdom articulated by the general semanticist Wendell Johnson (1956): “We see the world through categories.” Because the process of scientific discovery is more about uncertainty than certainty, teachers instill in their students an awareness that *revisions in category usage*—including their own creative revisions—may hold the key to the next penetrating advance in any discipline. Drawing from their own first-hand experience, these emerging scholars hold that progress, in science and other human endeavors, takes place through advances in terminology (Waters, 2017b).

Another noteworthy long-term gain is in the way young scholars exposed to this pedagogical strategy envision their role in enhancing the accessibility of their research findings to the public. By placing a spotlight on the communication gap between researchers and nonresearchers, the courses collectively provide discoverers-in-training with a much-needed roadmap for conveying their research to the public. Their learning experience shapes how they labor intellectually, lingering longer in their manuscript preparation, with active attention paid to effectively communicating their new ideas, rather than passively accepting formulaic methods of academic writing. Here, some utilize their hard-won skill of summarizing a manuscript in a single statement using lay-friendly language. They see the collection of words they select to describe their work and the works of others in their discipline as an act that carries deep responsibility. Called upon are their full abilities to deconstruct and reconstruct discourses pertaining to an ever-expanding breadth of subject matter. These scholars stand ready to assist the public as they come face-to-face with an information explosion deficient in critical context.

Against this backdrop of substantial potential gain, what limiting factors present the most formidable challenges to replication of this pedagogical approach? Here, we are inclined to consider limits to replication as residing within three categories related to (1) instructor, (2) student, and (3) institution. Undoubtedly, achieving sufficient instructional quality is a crucial factor for successful implementation. An instructor’s effectiveness will likely hinge upon her expertise in the biology of aging, specifically her ability to present ideas that build upon one another, rather than delivering a sterile litany of two dozen or more theories of aging presented in isolation. The instructor should demonstrate a solid understanding of and commitment to the high degree of benefit that can be derived from challenging students to learn aging from a cross-disciplinary perspective. The effective instructor must safeguard against falling into the trap of specialized one-dimensionality, sinking into her own area of expertise for each explanatory venture, for example, each aging concept is embellished by offering an example related to the study of cardiovascular disease.

Moreover, the instructor must embrace *the primacy of language*—its limits, its possibilities—as it relates to promoting the personal growth and transformation of students. The well-equipped instructor will possess the ability to teach the language of biology, the language of scientific inquiry, in a nonintimidating manner. This capacity likely hinges upon the instructor’s ability to reach out and connect with students from different disciplines, listening attentively to locate each student’s lexical starting points, along with a willingness to build upon the ideas that students currently hold as compelling. Ideally, the instructor’s attitude toward language precision will position her to become a model of eloquence to which the students will aspire. This will mean travelling beyond external eloquence to achieving an

internal eloquence—a heightened capacity to use language as a thinking tool to achieve creative excellence (Waters, 2017a). It is not unreasonable to posit that graduate students at our institution who are veterans of this pedagogical exposure emerge uniquely qualified, readied to replicate this strategy within other institutional environments.

It would be shortsighted to envision the limitations of replicability of any learning opportunity as depending exclusively upon the attitudes and capabilities of the instructor. Successful replication likely depends upon certain student characteristics, namely a receptivity to interdisciplinary rigor. Students may be skeptical about the benefits of venturing outside the silo of their specialized training to energetically seek a “wider equilibrium.”² Students may also have their preconceived notions about effective learning violated by the idea that access to the biology of aging can be achieved by developing an attitude of language precision, instead of through a more conventional, knowledge content-driven pedagogical approach. Particularly for students in the life sciences (in contrast to students in the humanities), seeing precision in language as gateway to getting inside any domain is likely to be approached with a strong initial skepticism that the instructor and student will need to overcome.

Fortunately, such student-based limitations have not been particularly problematic at our institution. This is likely because our graduate students are recruited into an institutional framework that fosters interdisciplinarity. The vast majority of students exposed to this pedagogical strategy are PhD candidates in pursuit of a dual-title PhD in gerontology, which demands a commitment to extend their scholarly training *outside their specialized discipline* (e.g., sociology or pharmacy) to include coursework and thesis research pertinent to gerontology. At our institution, The Biology of Aging course (but not the other three courses) is required for completion of the dual-title PhD in gerontology. In an age of increasing specialization, including a burgeoning of clinical certification requirements for specialized coursework, institutions may find it difficult to provide learning opportunities that reinforce the value of interdisciplinary training. Moreover, recent institutional trends that limit the number of elective courses and pare down nonrequired (elective) or extradepartmental classroom credit hours further threaten the prioritization of institutional resources for nurturing rich, cross-disciplinary perspectives. Clearly, an institutional culture that prizes authentic interdisciplinary learning provides the most suitable environment for the cross-disciplinary innovation in gerontological education that we outline here.

Seizing opportunities to nurture interdisciplinary spirit

On the surface, the interdisciplinary measure of the course offerings described here, if viewed narrowly, could be reduced to merely the introduction of nonbiologists to biology. But we envision that an even larger opportunity has been created. This contention is nested in the idea that *our pedagogical approach creates an expectation of interdisciplinary inquiry in every student*, moving biologists and nonbiologists beyond their area of specialized training to take a more integrated view of the aging process, providing an approach that is infused with a rich collection of perspectives from the instructor and classmates from other disciplines. Under the sway of this expectation of interdisciplinarity, each student begins as a specialist-in-training seeking an educational experience that will balance, broaden, and eventually transcend her specialized ways of seeing by willfully engaging in out-of-silo classroom encounters. Students exercise their

desire to gain ways of thinking beyond discipline-specific strategies to include approaches that work across disciplines, which may include particular approaches that may be shared with, or distinct from, other disciplines. Not just brushing up against new ideas but rather achieving a transformation of their method that will enable them to engage in rich discourse and in the integration of knowledge with specialists of other disciplines. The educational opportunity that we have created is truly interdisciplinary (rather than multidisciplinary) in the sense that its intent is to provide a starting point for trainees to move beyond the simple contrasting of different ideas to a *goal of ownership of integrated ideas*, which emanates from the identification of key potential linkages, a willingness to blur disciplinary boundaries, and the construction of conceptual frameworks derived from multiple disciplines (Choi & Pak, 2006).

Within a structure conceived by the instructor and fostered by fellow students, eager students are afforded an opportunity to escape from specialized thought, acquiring the cross-disciplinary thinking skills needed to match these cross-disciplinary expectations. In our experience, the escape from specialized thought can be contagious. For example, students from social sciences spread ideas such as life course perspective that infect previously unexposed life sciences students who believe that studying aging means closely observing old rats or old zebras, instead of paying careful attention to critical early-life events that shape aging trajectories. So too does the audiologist in training spread new thinking about the problem of “why grandpa has lost his sense of humor”—impaired hearing gobbles up so much effort in just collecting sense data that grandpa has insufficient cognitive room to engage in the juxtapositional word play that constitutes humor. Rather than having irreversible cognitive loss, grandpa’s performance might be rescued by an assisted hearing device.

The value and uniqueness of such cross-disciplinary educational encounters indicate that this sort of pedagogical approach can travel well beyond the rescuing of nonbiology students from a biology headache. Each classroom provides an incubator for those students who are motivated to grow their own thinking to the very edge of their disciplinary thinking, so they might “cross over” to engage problems in a new way. As a consequence, the ground is prepared for students to engage in unconventional learning experiences that they now see as vital to overcoming the very challenge that interdisciplinary education attempts to address, *How do we best prepare ourselves—as faculty and students—to confront complex intellectual problems that will require the cross-disciplinary expertise of multidisciplinary and interdisciplinary teams?*

Conclusion

A pedagogical strategy situating the biology of aging as an accessible part of interdisciplinary graduate training is presented. The approach features a highly approachable gateway course—The Biology of Aging—which enables students to experience first-hand how language precision is essential to gaining access to any discipline. Three additional course offerings reinforce this instructional strategy. Taken together, this four-pronged learning opportunity, which envisions exactitude with language as essential to intellectual growth, provides a rich framework for making complex topics in the biology of aging accessible to nonbiologists and biologists alike. By inspiring students to master language in the key of B—Biology of Aging—we have created a method for developing scholars

prepared for a lifetime of seeing and reporting. For nonbiologists, this means students growing to see their research questions not only through their disciplinary lens of sociology, anthropology, psychology, or economics, but also through the lens of a moving, yet-to-be-fully-understood physiology of the aging process. By placing emphasis on cultivating an attitude of precision with language, students are provided a tool—not just for boosting the quality of their thinking, but for building a robust cross-disciplinary vocabulary, which bolsters their confidence in becoming productive members of multi-disciplinary and interdisciplinary teams, and significantly shapes their own pedagogical style.

Science is a method of perception, not a collection of facts (Bateson, 1979). As discoverers and educators, we will benefit from the awareness that, when we employ the scientific method, we are attempting to make sense of a world of words, rather than hold on to the illusion that words and categories do not stand between us and Nature (Waters, 2017b). When it comes to preparing tomorrow's leaders in geriatrics and gerontology, this realization has led us to consider a new educational prescription—one in which creative excellence in the life sciences is informed and catalyzed by the humanities (Waters, 2017a, 2017b). Our implementation of this reckoning, manifest in the progress we have sketched out here, reflects an authentic motivation to create circumstances for students and faculty that will help to innovate learning, bringing within reach a pedagogical approach that will break down barriers and address an unmet need in interdisciplinary gerontology education.

Notes

1. With these features, the Biology of Aging course achieves a pedagogical structure that parallels many of the aspects of educational philosophy put forward by George Herbert Mead in his 1910 to 1911 lectures delivered at the University of Chicago titled “A Philosophy of Education” (Mead, 2008).
2. *Wider equilibrium* is a term used by I. A. Richards to refer to the payoff for cross-disciplinary ventures in his book *Poetries and Sciences* (1970), one of the acts of writing to which students are exposed in the course More Effective and Opportunistic Writing.

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