

**INTRODUCTION**

Many widely used academic vocabulary lists have been developed for adult populations which may not be a good fit for use in K-12. This report describes the creation of a new vocabulary resource for K-12, based on a corpus of approximately 40 million running words, drawn from the top four best-selling textbook programs in science, math, social studies, and reading/ELA all published since 2011.

In addition to word frequencies and other usage statistics for all words found in the textbooks, MetaMetrics developed lists of general and domain-specific academic vocabulary words by grade. The lists of academic words were then compared to two widely used academic word lists — the Academic Word List (AWL) (Coxhead, 2000) and the Academic Vocabulary List (AVL) (Gardner & Davies, 2014).

**What is academic vocabulary?**

Academic words are words that are used more frequently in textbooks or other academic contexts and not as frequently in oral language or narratives (Baumann & Graves, 2010; Nagy & Townsend, 2012; Baker, et al., 2014). Although some researchers divide academic vocabulary into a greater number of categories (e.g., Hiebert & Lubliner, 2008), MetaMetrics considers academic vocabulary as existing in two main categories: domain-specific and general. Domain-specific academic word use is concentrated within a single domain (e.g., photosynthesis, quantity, or democracy) and general academic words are used across many domains (e.g., analyze, interpret, consequence).

**Why focus on academic vocabulary?**

Academic vocabulary is increasingly acknowledged as representing a unique and important challenge for readers and a proposed area of focus for educators. Theoretically, academic vocabulary is integral to the background knowledge essential for comprehending text, learning new words, and expanding existing concepts through reading and discussion (Elleman, Olinghouse, Gilbert, Compton, & Spencer, 2017; Lesaux, 2012).

Domain-specific academic vocabulary words, such as “glacier” or “democracy,” represent the topic knowledge necessary for successful comprehension. While for general academic words, advocates argue that attention should be focused on words that will occur again and again over many contexts (Coxhead, 2000; Lesaux et al., 2010; Nagy & Hiebert, 2011; Gardner & Davies, 2014).

Some evidence suggests that academic vocabulary contributes to comprehension even independently of other academic language skills (Uccelli, Phillips, Galloway, Barr, Meneses, & Dobbs, 2015). Since this suggests that it is the particular words that improve comprehension, it follows that focusing attention on the words most likely to be encountered in school reading should have the most impact for school-age students.

Additionally, many researchers argue that learning academic words early can facilitate future reading comprehension (e.g., Hirsch, 2006; Willingham, 2006; Elleman, Olinghouse, Gilbert, Compton, & Spencer, 2017; Wright & Gotwals, 2017). Therefore, up-to-date information about which words will be relevant for early grades is of particular interest for improving reading and listening comprehension outcomes throughout the grades.

**Why create new academic vocabulary lists?**

There are several reasons that existing academic vocabulary lists are not ideal for K-12, but it mostly comes down to a single issue: K-12 learners have largely not been the target population for list developers. A significant portion of the empirical research on academic vocabulary is rooted in an English-language learner context (Snow & Ucelli, 2009). One of the most widely used academic vocabulary lists, the Academic Word List (Coxhead, 2000), is directed to adult English language learners. The Academic Vocabulary List (Gardner & Davies, 2014) was not explicitly directed to ELL populations, but was still developed from materials intended for adults (e.g., newspapers, books, scientific journals and magazines, etc.). The quality of these prior works is not called into question, instead this research by MetaMetrics can be understood as a replication and extension specifically targeted at K-12.

Some empirical research on academic vocabulary in K-12 texts exists and some lists have been developed with K-12 readers in mind. Bailey (2007) investigated academic vocabulary in school texts, but examined only 5th grade materials. Greene & Coxhead (2015) studied which subset of words in the AWL were also present in middle school texts. However, this study was unable to identify any relevant academic words for middle school that were not already present on the AWL. Marzano and colleagues (2004) developed a number of domain-specific academic vocabulary lists for K-12, but they were derived from curricular documents rather than the texts students read.

**Why calculate new word frequencies?**

In addition to a desire to generate new academic wordlists based on the words students are actually likely to encounter, MetaMetrics also observed a need to regenerate estimates of word frequency for K-12 students. The most recent systematic effort to do so was the *Educators Word Frequency Guide* published by Zeno, et al. in 1995. It has been documented that textbooks have changed substantially since the '80s and '90s (e.g., Fitzgerald, et al., 2016), and so new estimates of the word frequency are necessary to determine which words students are likely to encounter in their contemporary school reading materials.

**OBJECTIVE****Goals of the Present Study**

The present study addresses the lack of K-12 academic vocabulary word usage data and word lists with up-to-date and relevant evidence from contemporary, best-selling textbook programs. There are three explicit goals:

1. Develop new word frequency and usage measures for words likely to be encountered by K-12 learners.
2. Develop new general and domain-specific academic vocabulary lists by grade.
3. Compare the new general and domain-specific academic vocabulary lists with existing lists of academic words by asking two questions: (a) to what extent do existing lists include words not likely to be encountered by students at different grade levels? and (b) to what extent are there important general academic vocabulary words present in textbooks that are not present on existing lists?

**METHODS & DATA SOURCES**

The study comprised three phases corresponding to the three stated goals. First, text processing and calculation of word frequency and usage measures were conducted. Second, identification of academic vocabulary words based on a computational model of academic vocabulary trained by expert judgment. In the third phase, the word lists generated by the model are compared with two popular existing lists of general academic words, the Academic Word List (Coxhead, 2000) and the Academic Vocabulary List (Gardner & Davies, 2014).

**Phase 1: Text Processing and Calculation of Word Frequency and Usage Measures**

Four current, best-selling (Education Market Research, 2014) disciplinary textbook series were identified in each of four disciplines—science, social studies, mathematics, and core-reading. The textbooks were digitized and edited according to a standardized protocol with the overarching goal of including all words children were intended to read and excluding words primarily for teachers’ benefit. For example, callouts for Common Core State Standards were excluded.

Similar to Coxhead (2000) and Gardner and Davies (2014), we examined patterns of word use across domains. Specifically, we calculated a dispersion measure and bias measures for each domain (Gries, 2008). The logic behind these measures is that domains-specific words tend to occur mostly in one domain (e.g., biosphere has low dispersion and is biased towards occurrence in science texts) whereas general academic words tend to have high dispersion and low biases towards any particular domain.

Beyond individual word use patterns, and in departure from previous work, we examined constellations of semantically related words identified by a probabilistic neural network language model (Le & Mikolov, 2014) and used them to develop additional measures to identify domain-specific and general academic words based on their meanings not just their individual pattern of usage. For each word usage measure (dispersion, bias, etc.), we calculated “neighborhood” measures based on each target word’s set of semantically related words.

To concretize the need for additional semantically derived measures of word usage, consider the following example. While the word “pizza” is biased heavily towards math textbooks as an example for proportions, the constellation of related pizza-words (e.g., cheese, pepperoni, tomatoes, etc.) are not generally biased towards occurring in math textbooks, and so the “neighborhood math bias” for the word pizza is relatively low compared to a word like “integer” which is both biased towards math texts and has a high “neighborhood math bias” since many words related to integer are also math specific words.

**Results**

We identified approximately 45,000 words students may encounter in their school reading, after removing OCR errors, misspellings, and non-English words and wherein a word is defined as a word family consisting of all inflected forms of verbs and plural nouns (e.g, jump, jumps, jumping, jumper, jumpers, jumped). Affixed or derived forms of words beyond those categories (e.g., power/powerful, act/active/activist) are considered as unique words. Table 1 contains a sample of word frequency measures by grade and domain.

**Table 1: Word Frequency by grade and domain. Sorted by frequency in grade 1, descending.**

	Grade 1	...	Grade 5	...	Science Textbooks	Math Textbooks
<b>the</b>	16,104		113,121		669,361	571,917
<b>a</b>	9,475		44,625		284,957	268,962
<b>to</b>	7,528		43,039		189,736	160,260
<b>and</b>	6,795		41,072		216,909	163,782
<b>is</b>	5,419		18,319		161,696	152,567
			...			
<b>cheetah</b>	1		10		95	49
<b>creative</b>	1		30		113	79
<b>parachute</b>	1		11		120	20
<b>crash</b>	1		68		285	21
<b>partition</b>	1		16		29	230

**Phase 2: Identifying Academic Words**

We created lists of academic words, both domain-specific and general, in a manner similar to that of Coxhead and Gardner & Davies, using the word usage measures calculated from the textbooks in phase 1. Although aspects of our process were the same as those used for the AWL and AVL, such as examining relative frequency within and across domains, our effort included two additions: a) additional word characteristics including features of the semantic networks in which words appear and b) a new approach to validating the lists by conducting an expert judgment study to evaluate the degree to which our lists contained the same words identified by subject matter experts as general or domain-specific academic words.

Model training and validation by expert judges

Using a well-defined set of rules, two judges were trained to identify words as academic words and assign them to domains or to the general academic category. A random sample of words from the textbooks was drawn and the two judges independently assigned each word to one of five categories: not academic, science academic, math academic, social-studies academic, and general academic. Reliability of judgments was assessed and a probabilistic classification model was developed using the expert judgments as a target (Breiman, 2001). Accuracy of the classification model was assessed against expert judgments for each academic category.

Assigning words to grades

The grades at which words are most relevant is of practical value to many educators, content authors, publishers, assessment makers, and others. Although words are almost always used across a range of grades, it is useful to assign words to a single grade at which we believe they would be most relevant in the sense of occurring most frequently in that grade.

Based on the different volume of reading at each grade, we created lists of increasing size with the following procedure: Start at first grade, select the top N most frequent academic words for each domain and assign them to grade one. Next, repeat the process for grade two, excluding words that appeared on the grade one list. Continue with grade three up to grade twelve. Where N for each grade is determined by the relative number of unique words appearing in that grade compared to other grades.

**Results**

The two experts made judgments on 1,869 words. Reliability between judges was between 90 and 95%. Model classification accuracy was 90%, 96%, 90%, and 89% for science, math, social studies, and general respectively. Words were included on a list if a) the model predicted an expert judge would identify the word as an academic word, b) a student would be expected to encounter a word at least 10 times, and c) the word did not appear on the list of proper nouns and was not identified as a Spanish word.

In total 6,236 words were identified as academic words. A further expert review identified 224 words (3%) to be removed from the list for not meeting the definition of academic vocabulary leaving a total of 6,013 academic words. Tables 2 and 3 provide counts and examples by grade and domain.

**Table 2: Counts of academic words by domain and grade.**

	1	2	3	4	5	6-8	9-12	Overall
<b>Science</b>	74	119	174	205	238	657	1,015	2,482
<b>Math</b>	12	16	25	30	35	95	142	355
<b>Social Studies</b>	62	101	145	176	201	545	846	2,076
<b>General</b>	34	56	80	97	111	300	466	1,144
<b>All Academic</b>	178	290	422	505	579	1,575	2,464	6,013

**Table 3: Sample academic words by domain and grade.**

	1	3	5	6-8	9-12
<b>Science</b>	mammal melt cub	geologist nectar magnetism	fuse cavity pest	heterotroph canopy carbonate	lactic peptide cytosine
<b>Math</b>	graph equal unit	commutative compute graphic	factorization coordinate ratio	portion regression transversal	polyhedra nonadjacent removable
<b>Social Studies</b>	citizenship volunteer grace	nonprofit enslave merchant	eligible commerce aqueduct	peasant decree assault	multiparty arbitration armament
<b>General</b>	addition sentence essential	similar express evaluate	version representation propose	favorable dynamic motivation	induce moderate plentiful

### Phase 3: Word List Comparisons

Different lists use different units of analysis and so adjustments had to be made for meaningful comparisons. For example, Coxhead included word families that contained many derived forms of a word (act, action, reaction, reactionary, etc.) whereas Gardner and Davies used an inflection-based word family and differentiated by part-of-speech. For the present study, to ensure comparable analyses across the prior lists and the textbook-based lists, the three lists were modified to represent families of a base word, its plural, and its verb inflections. Part-of-speech was not considered.

Comparing words on each list and examining their frequency of occurrence in the textbooks, we sought to answer our two questions:

1. To what extent do existing lists include words not likely to be encountered by students at different grade levels?
2. To what extent do the newly created lists contain important general academic vocabulary words present in textbooks that are not present on existing lists?

### Results

Examining word frequency in the textbooks, we assessed how many words on each list were unlikely to be encountered and examined differences in the overall number of word encounters expected between lists. Because of the particular importance of early vocabulary learning, we considered both grades 1-5 only and occurrence overall in the textbooks.

For both the AVL and AWL, over half of the words on the list would not be expected to be encountered even once by a student in grades 1-5. Comparing words at the median level of frequency, students would be expected to encounter words on the AWL, AVL, and general academic word lists 59 times, 44 times, and 172 times respectively over the entire span of grades from 1 to 12. That is to say, the median word on the newly developed lists would be expected to be encountered about three times as much as the median word on either the AWL and AVL.

To address the second question of whether there were important academic words that appeared in the textbooks but not in the existing lists, we examined how many words appeared on the newly developed academic vocabulary lists drawn from the textbooks but that did not occur on one or both of the existing lists. Of the 1,144 general academic words on the newly developed list, 751 do not occur on the AWL and 499 do not occur on the AVL. A random sample of 10 words occurring on the general academic list but not on the AVL or AWL reveals a variety of words one can imagine being important for grade school learners: *simplicity, appeal, circulation, plagiarism, prevent, opposite, nominative, counterargument, phrase, chronological*.

## CONCLUSION & DISCUSSION

We found that two widely used academic word lists both contain words that are unlikely to be encountered by K-12 readers (especially in elementary grades) and omit important academic words that are likely to be encountered repeatedly in school reading. Additionally, for words on existing lists that do occur in the textbook corpus, they tend to occur much less frequently than words on lists developed specifically for K-12. In short, word lists created for adult and ELL audiences are not ideal for use in K-12 classrooms. Regardless of type of instruction, if time is spent on words that students are unlikely to encounter or important words are omitted from focus because they were not relevant for the original study audience, then vocabulary learning will likely be negatively impacted. Focusing instruction and assessment on words students are more likely to encounter logically should result in greater gains in reading comprehension and vocabulary and knowledge growth.

## IMPLICATIONS FOR PRACTITIONERS

First, we should note that this resource, like any other, should be used thoughtfully and as one element of a comprehensive program of vocabulary and knowledge development. Many researchers comment on the need to limit “prescriptive” use of word-lists (Snow & Uccelli, 2009; Nagy & Townsend, 2012; Beck, McKeown, & Kucan, 2013). Nagy and Townsend make clear that even limiting ourselves to academic vocabulary, there is far more to the construct than just the words. Words themselves “are not isolated units of language” (Nation, 2001, p. 23) and knowing a word deeply involves knowing many other words (Neufeld, Hancioğlu, & Eldridge, 2011; Fitzgerald, Elmore, Relyea, Stenner, in press). For this reason, use of word lists, disconnected from meaningful contexts, is suspect as an effective teaching tool.

Despite controversies about the use of word lists however, if word lists are to be used in research or practice, it is important to understand the extent to which they represent words that grade-school students will likely encounter in their school reading and as much as possible focus instructional attention on the words students will need for their school reading.

MetaMetrics has released two resources to address these needs, based on the findings described in this report: **Lexile® WordBank** and **Lexile® WordLists**. Lexile WordBank is a licensable vocabulary resource that provides content, curriculum and assessment developers with information about the words students will likely encounter in their school reading. Lexile WordLists is an online tool where you can create custom academic word lists by grade and domain available on the **Lexile® & Quantile® Hub** at [hub.lexile.com/wordlists](http://hub.lexile.com/wordlists).

## REFERENCES

- Baker, S., Esther, G., Kieffer, M.J., Lesaux, N., Linan-Thompson, S., Morris, J., Proctor, C.P., & Russell, R. (2014). *Teaching academic content and literacy to English learners in elementary and middle school (NCEE 2014- 4012)*. Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.
- Bailey, A. L., Butler, F. A., Stevens, R., & Lord, C. (2007). Further specifying the language demands of school. In A. L. Bailey (Ed.), *The language demands of school: Putting academic English to the test* (pp. 103-156). New Haven, CT: Yale University Press.
- Baumann, J. F. & Graves, M. F. (2010). What is academic vocabulary? *Journal of Adolescent and Adult Literacy*, 54: 4–12

- Beck, I. L., McKeown, M. G., & Kucan, L. (2013). *Bringing words to life: Robust vocabulary instruction (2nd ed.)*. New York: Guilford.
- Breiman, L. (2001). Random forests. *Machine Learning*, 45, 5-32.
- Coxhead, A. (2000). A new academic word list. *TESOL Quarterly*, 34, 213-238.
- Davies, M. (2008-) The Corpus of Contemporary American English (COCA): 520 million words, 1990-present. Available online at <http://corpus.byu.edu/coca/>.
- Education Market Research. (2014). *Reading market 2012*. New York: Author.
- Elleman, A. M., Olinghouse, N. G., Gilbert, J. K., Compton, D. L., & Spencer, J. L. (2017). Differential effects of strategy instruction for younger and older elementary students. *Elementary School Journal*, 118, 232-256.
- Fitzgerald, J., Elmore, J., Relyea, J., Hiebert, E.H., Stenner, A.J. (2016). Has First-Grade Core Reading Program Text Complexity Changed Across Six Decades? *Reading Research Quarterly*. 51. 10.1002/rrq.115.
- Fitzgerald, J., Elmore, J., Relyea, J. E., & Stenner, A. J. (in press). Domain-specific academic vocabulary network development in elementary grades core disciplinary textbooks. *Journal of Educational Psychology*. Advance online publication. <https://doi.org/10.1037/edu0000386>
- Gardner, D., & Davies, M. (2014). A new academic vocabulary list. *Applied Linguistics*, 35, 305-327.
- Greene, J. W., & Coxhead, A. (2015). *Academic Vocabulary for Middle School Students*. Baltimore MD: Brookes Publishing.
- Gries, S. (2008). Dispersions and adjusted frequencies in corpora. *International Journal of Corpus Linguistics*, 13, 403-437
- Hiebert, E. H., & Lubliner, S. (2008). The nature, learning, and instruction of general academic vocabulary. In A. E. Farstrup & S. J. Samuels (Eds.), *What research has to say about vocabulary instruction* (pp. 106-129). Newark, DE: International Reading Association.
- Hirsch, E. D. (2006). Building knowledge: The case for bringing content into the language arts block and for a knowledge-rich curriculum core for all children. *American Educator*, 30(1), 8-17
- Hyland, K. & Tse, P. (2007). 'Is there an "Academic Vocabulary"?' *TESOL Quarterly* 41: 235-53
- Le, Q. & Mikolov, T. (2014). Distributed representations of sentences and documents. *In Proceedings of the 31st International Conference on International Conference on Machine Learning*, 32, 1188-1196.
- Lesaux, N. K., (2012). Reading and Reading Instruction for Children from Low-Income and Non-English-Speaking Households. *Future of Children*, 22(2), 73-88
- Lesaux, N. K., Kieffer, M. J., Faller, S. E., & Kelley, J. G. (2010). The effectiveness and ease of implementation of an academic vocabulary intervention for linguistically diverse students in urban middle schools. *Reading Research Quarterly*, 4, 196-228.
- Marzano, R. J. (2004). *Building background knowledge for academic achievement*. Alexandria, VA: Association for Supervision and Curriculum Development.
- Nagy, W., & Hiebert, E. (2011). Toward a theory of word selection. In M. L. Kamil, P. D. Pearson, E. B. Moje, & P. P. Afflerbach (Eds.), *Handbook of Reading Research* (pp. 388-404). New York: Routledge.
- Nagy, W. & Townsend, D. (2012). Words as tools: Learning academic vocabulary as language acquisition. *Reading Research Quarterly* 47: 91-108
- Nation, I. S. P. (2001). *Learning vocabulary in another language*. Cambridge: Cambridge University Press.
- Neufeld, S., N. Hancioğlu, & J. Eldridge. (2011). Beware the range in RANGE, and the academic in AWL. *System*, 39: 533-8.
- Snow, C. E., & Uccelli, P. (2009). The challenge of academic language. In Olson, D. R., & N. Torrance (Eds.), *The Cambridge Handbook of Literacy* (pp. 112-133). Cambridge: Cambridge University Press.
- Uccelli, P., Galloway, E.P., Barr, C, Meneses, A., & Dobbs, C. (2015). BeyondVocabulary: Exploring Cross-Disciplinary Academic-Language Proficiency and Its Association with Reading Comprehension. *Reading Research Quarterly* 50(3): 337-356
- Willingham, D. T. (2006, Spring). Knowledge in the classroom. *American Educator*. (No volume number or pages available.)
- Wright, T. & Gotwals, A. (2017). Supporting Kindergartners' Science Talk in the Context of an Integrated Science and Disciplinary Literacy Curriculum. *The Elementary School Journal*, 117, 10.1086/690273.

For more information, visit [www.MetaMetricsInc.com](http://www.MetaMetricsInc.com).

MetaMetrics® is focused on improving education for students of all ages. The organization develops scientific measures of academic achievement and complementary technologies that link assessment results with instruction. For more than twenty years, MetaMetrics' work has been increasingly recognized worldwide for its distinct value in differentiating instruction and personalizing learning. Its products and services for reading, mathematics and writing provide valuable insights about academic ability and the potential for growth, enabling students to achieve their goals at every stage of development.

