Validating a Short Form Writing Attitudes Survey for Engineering Writers

Ellen Zerbe, Pennsylvania State University, University Park

Ellen Zerbe is a PhD candidate in Mechanical Engineering at Pennsylvania State University. She earned her B.S.M.E. at Grove City College. She is currently researching under Dr. Catherine Berdanier in the Engineering Cognition Research Laboratory.

Dr. Catherine G.P. Berdanier, Pennsylvania State University, University Park

Catherine G.P. Berdanier is an Assistant Professor in the Department of Mechanical Engineering at Pennsylvania State University. She earned her B.S. in Chemistry from The University of South Dakota, her M.S. in Aeronautical and Astronautical Engineering and Ph.D. in Engineering Education from Purdue University. Her research interests include graduate-level engineering education, including inter- and multidisciplinary graduate education, online engineering cognition and learning, and engineering communication.

Prof. Natascha Trellinger Buswell, University of California, Irvine

Natascha Trellinger Buswell is an assistant teaching professor in the department of mechanical and aerospace engineering at the University of California, Irvine. She earned her B.S. in aerospace engineering from Syracuse University and her Ph.D. in engineering education from the School of Engineering Education at Purdue University. She is particularly interested in teaching conceptions and methods and graduate level engineering education.

Joana M. M. Melo, Pennsylvania State University

Joana M. M. Melo is a doctoral candidate in Architectural Engineering at the Pennsylvania State University. She earned her B.S. in Chemical Engineering from ISEP in Portugal, and her master's degree in Energy for Sustainable Development from UPC in Spain. Joana has a passion for understanding how engineering students think and learn. Her research interests include graduate-level engineering education, quantitative methods for engineering education research, and thermal energy-efficient technologies.

Validating a Short Form Writing Attitudes Survey for Engineering Writers

Abstract: The objective of this research paper is to present the development and validation of a short-form survey that can be used to easily assess primary attitudes that engineering students hold as they approach academic writing. Engineering writing is a competency that is often-cited as a crucial skill for engineers to develop but is often under-emphasized in undergraduate or graduate curriculum. The affective dimension of writing (feelings, emotions, writer's block, and writing apprehension) can further complicate the process of writing for students who write infrequently. For graduate students, in particular, attitudes about writing have implications on career trajectory, persistence, and well-being in graduate school. The purpose of this research is to understand how graduate engineering student attitudes toward writing affect career trajectory, attrition, and persistence. Our prior research employs a series of previously-developed scales assessing various dimensions of writing attitudes and behaviors as a way to understand multiple dimensions of a student's affective relationship with writing; however, the survey is long (~30 minutes) and can be time-consuming for researchers to analyze. Each of the scales within the survey studies an aspect of the writer's attitudes. This research employs confirmatory factor analysis to develop a short form survey that gives accurate results, such that students can take a web-hosted writing attitudes survey and immediately be given their "writing attitude profile" with writing strategies tailored to their specific writing profile.

Introduction and Literature Review

Engineering writing is a competency is an oft-cited competency necessary for success in academic engineering and graduate school [1]–[7]; however, few graduate-level engineering programs have dedicated initiatives to increase graduate student writing proficiency [8]–[11]. While writing centers and similar initiatives can be useful, ultimately, at the graduate level, students need to develop literacy within their technical disciplines to anticipate the needs, values, and requirements for written communication within a disciplinary community [12]–[15]. Further, writing is an attitude that is easily affected by attitudes and perceptions [16]–[18], manifesting in issues related to writing apprehension [19], [20], writer's block [21], [22], and procrastination [23], which serve to further propel attitudinal issues with writing. As part of a larger, funded study, our purpose is to understand how graduate engineering student attitudes toward writing affect career trajectory, attrition, and persistence, positing that—although perhaps not the sole reason for a particular trajectory to, through, or out of engineering graduate programs—graduate student attitudes toward writing can push students to follow potential pathways.

Our previous research sought to assess the attitudinal dimension of writing using a variety of existing scales developed from the disciplines of English Composition and Rhetoric and Psychology, disciplines that have long-subscribed to the idea that students' attitudes toward writing impact their performance and competency in writing [16], [18]. In a nationwide survey of over 800 graduate engineering students, we collected data from five existing surveys studying writing attitudes in some way, some of which are specific to graduate students, and some of which were modified slightly to reflect academic writing in an authentic disciplinary context instead of in the classroom. While effective at capturing interesting information regarding graduate engineering students' attitudes and perceptions about writing and the writing process, the survey itself is quite long, averaging participants over 30 minutes to complete. Most interesting were

graduate engineering student responses to two of the surveys given, which will be discussed at length later and are described in our prior work.

Literature suggests that survey fidelity decreases with longer surveys, due to "survey fatigue" [24] in which participants lose focus or care over their answers, an unwelcome phenomenon in the collection of data. Therefore, the purpose of this paper is to present a short form of the survey which consists of only the survey items that most highly predict writing attitudes. The next section will introduce the two surveys that yield the most interesting data for engineering writing interventions, reviewing the broader study and briefly reviewing what our work has found to date in order to further motivate the development of an accurate short-form of the survey for broader, higher-impact use. The objective of this research paper is to present the development and validation of a short-form survey that can be used to easily assess primary attitudes that engineering students hold as they approach academic writing. It is necessary that this short-form survey is as robust as the original long-form survey at discerning users' writing attitudinal patterns.

Presentation of Surveys and Findings to Date

The survey on which we are distilling the short-form writing survey originally comprised five individual scales in addition to demographic informational questions, and information about future anticipated career trajectories. The purpose of deploying a battery of writing scales was (1) to discern how, if at all, attitudes toward writing presented in different scales correlated with each other; (2) to characterize dominant patterns or characteristics generalized over a large nationwide population of engineering graduate students, and (3) also assess students' writing attitudes in relationship with their research self-efficacy, a topic on which students are more used to being assessed. As part of a larger mixed-methods research design, the entire scale is deployed to currently-persisting engineering students and non-completers in order to assess if and how writing attitudes may link with attrition or persistence rates. Interviews with selected participants are also conducted to further explore graduate socialization and implicit or explicit patterns of thought about academic engineering writing. The five separate Likert scale surveys deployed are previously published and validated in literature [25]: (1) Inventory of Graduate Writing Processes [26], (2) Self- Regulatory Efficacy for Writing [27], (3) Graduate Concepts of Academic Writing [28], (4) Daly-Miller Writing Apprehension Scale [29], and (5) the Research Self-Efficacy Scale [30].

Two of the scales, the **Inventory of Graduate Writing Processes** and the **Graduate Concepts of Academic Writing** yield the most interesting results and have been a focus of much of our past work [31], [32]. These two scales and definitions of the factors within the scales are presented in Table 1. Our past work has found statistically significant correlations between many of the constructs between the scales. Of interest is the "trifecta" of low writing self-efficacy, procrastination, and perfectionism tendencies that occur in engineering writers, which frequently correlate. Further, and even more interesting, most engineering graduate student writers do perceive writing to be a "Knowledge Transforming" process, in which writing is generative and helps them to transform their scientific findings into useful knowledge for the community. Housed in this complex attitudinal map, we also find that engineering graduate student anticipated career trajectories are also linked with writing attitudes [33] —students who align with "strong" writing attitudes were more likely to consider several career trajectories, whereas students who aligned with "weak" writing attitudes, such as procrastination and low writing self-efficacy,

overwhelmingly anticipated avoiding academic careers and research R&D positions, instead anticipating they would go into an industry non-research job. These results indicate that student attitudes toward writing—not competencies, simply attitudes—affect how students anticipate future career options. We posit that to diversify the engineering professoriate, and we need to improve graduate student attitudes toward writing in order to "level the playing field," such that more students will at least consider academic engineering careers. Further, from an instructor point of view, knowing students' writing barriers can aid in discussions on writing strategies and potential interventions, as we discuss in other works [31], [32], [33].

Table 1 – Definition of Factors within Two Writing Surveys of Interest

Graduate Writing Processes [26]	**Graduate Concepts of Writing** [28]
Elaborative – *writing is a personal investment and part of knowledge creation*	**Blocks** – *experiences writing paralysis that inhibits the production of text*
Low Self-Efficacy – *exhibits lack of confidence in ability to articulate thoughts*	**Procrastination** – *puts off starting or working on writing tasks*
No Revision – *avoids or resists deep revision during writing*	**Perfectionism** – *strives toward perfection and may not make progress due to continuous revision*
Intuitive – *has an innate sense of writing and expectations; can "see" or "hear" an argument effectively when writing*	**Innate Ability** – *believes writing ability is a fixed attribute that cannot be taught*
Scientist – *follows a strict order to the writing process*	**Knowledge-Transforming** – *believes writing is a way to build and test knowledge and arguments*
Task-Oriented – *strong adherence to the "rules" of writing and may not see writing as a personal process*	**Productivity** –*able to make consistent progress when writing*
Sculptor – *fluent style of drafting but typically revises only after an entire draft is written*	

The Inventory of Graduate Writing Processes and the Graduate Concepts of Academic Writing scales have the added advantage of eliciting the most immediately-applicable feedback regarding engineering graduate student attitudes toward academic engineering writing. An individual's dominant attitudinal traits, discerned through the surveys, offer instructors starting points for offering individualized writing instruction or exercises to help students who struggle with a particular aspect of writing; for example, with writer's block or procrastination. However, these two surveys alone comprise a survey of 85 items (see Appendix for original surveys). Because of the usefulness of the compilation of our prior results, we expect that a short-form of these two surveys that can accurately represent the results of the full surveys, will be more easily deployed and more useful. In order to develop the short-form survey, we present a Confirmatory Factor Analysis to justify the selection of the final scale items and present a validation study using the data already collected against the results from the items employed in the short-form survey.

Methods

Long-form Survey Participants and Recruitment. Recruitment for graduate engineering student participants to participate in our larger research project was conducted in Spring 2018 via email with administrative assistants in engineering departments at ten research-intensive universities across the United States. While over 800 participants completed a portion of the study,

a total of N= 621 completed graduate students completed the entirety of the survey. Because the survey was long, completion was incentivized with a $5 Amazon.com gift card. A majority of participants identified men (61.0%), 37.8 % identified as women, and 1.1% of participants identified as another gender or did not wish to answer. 49.3% of participants identified as White/Caucasian; 35.8% identified as Asian/Pacific Islander; 8.1% identified as Hispanic or Latin American; 2.4% identified as African American or Black; 0.9% identified as Native American, Native Alaskan, or Native Hawaiian; and 2.2% of participants identified with another race or ethnic identify. The remaining 1.1% of participants did not wish to identify their racial or ethnic background. While 55.6% of participants were early-career graduate students (in their first two years of a Ph.D. program or MS-level students), 82.4% reported having started graduate-level research. 41% of participants responded identified as international students, and 39.1% of participants reported speaking a language other than English at home.

Statistical Analysis Methods: Confirmatory Factor Analysis. The development of short-form writing attitudes survey for engineering writers consisted of running a statistical analysis of writing scales of the original full-length survey using Confirmatory Factor Analysis (CFA), a statistical method that can be used to reduce the number of observed variables into a small number of variables by examining factor loadings among the observed variables [34]. This method helps to eliminate survey questions that contribute insufficient information to their associated factor [35]. In CFA, a structure is proposed in which the observed, measurable variables reflect only specific unobserved constructs [36]. In other words, this means using the observed variables from the questions of the survey to infer about the writing factors or unobserved variables. In practice, CFA tests one or more hypothesis about relations between observed variables and the factors [37].

CFA was executed using AMOS version 25 [38]. First, a CFA analysis was performed independently in each 13 factors to obtain the factor loadings. Second, a CFA analysis was performed separately for seven factors of writing attitudes and six factors of writing concepts, to compare factor loadings. Third, a CFA analysis was performed in data for the 13 factors simultaneously to compare with previous factor loadings. For the analyses of 7 factors of writing attitudes and the 13 factors simultaneously, the model presented a covariance matrix that was not positive definite. Therefore, task-oriented, the factor causing this challenge, was excluded. Next, a CFA analysis was performed in data for the 12 factors simultaneously to compare with previous factor loadings.

The next part of the analysis consisted of choosing the variables with the highest factor loadings and run an analysis with these variables. To do this, we tested three separate models that represent different criteria for selecting an appropriate number of items with sufficiently high factor loadings.

Model 1) Choose the three questions with the highest factor loadings for each of the 12 factors.

Model 2) Choose questions with factor loadings above 0.6 for each of the 12 factors, with a minimum of three questions per factor.

Model 3) Choose the four questions with the highest factor loadings for each of the 12 factors.

This analysis retrieved the factor loadings for the 12 factors with the reduced number of chosen variables. Then, factor scores were calculated for each of the participants, taking into account the short-form survey and the full-length survey. Finally, this study calculated correlations between factor scores. These correlations help to verify if the extracted factors chosen to the short-form survey were representative of the full-length survey. The model evaluation was performed with

goodness-of-fit measures, including chi-square (χ^2) [39], root mean square residual (RMR) and root mean square error of approximation (RMSEA). A model with RMR lower than 0.08 [34], and RMSEA lower than 0.08 [40] is considered a good fit model.

Results

Factor loadings. The standard factor loadings ranged from -0.28 to 0.71 for elaborative, from 0.09 to 0.73 for low self-efficacy, from 0.09 to 0.77 for no revision, from 0.20 to 0.56 for intuitive, from 0.20 to 0.51 for scientist, from 0.20 to 0.53 for sculptor, from 0.43 to 0.76 for blocks, from 0.66 to 0.80 for procrastination, from 0.31 to 0.70 for perfectionism, from 0.80 to 0.82 for innate ability, from 0.38 to 0.67 for knowledge transforming, and from 0.61 to 0.75 for productivity.

Goodness-of-fit indices. Table 2 presents the goodness-of-fit indices for the four models showing that all the models present an adequate data fit.

Table 2 - Goodness-of-fit indices

Model	# observed variables	χ^2	df	N	p	RMSEA	RMR
Original model	84	8682.6	3336	621	<0.001	0.051	0.061
Model 1	35	1270.0	494	621	<0.001	0.050	0.049
Model 2	39	1667.4	636	621	<0.001	0.051	0.052
Model 3	46	2456.7	923	621	<0.001	0.052	0.059

Factor scores. AMOS calculated factor scores for each of the N = 621 participants' answers. The average correlation between factor scores of the short-form vs. full-length survey was 0.956 for Model 1; 0.963 for Model 2; and 0.973 for Model 3. The factor score correlations analysis shows that the original 12-factor model can be represented by a shorter version, as the three analyzed shorter version models present correlations above 0.95.

As the purpose of this study is to develop a shorter version of the full-length survey that can be representative but also appealing to the respondents, we suggest the version with the lowest number of questions, which is Model 1. The finalized survey that supports this model is shown in Table 3. This model has 35 observed variables and a 0.956 correlation with the original long-form model with the 12 factors and 84 observed variables.

Table 3 - Proposed Short-Form Engineering Writing Attitudes Survey

	Factor Loadings
Factor 1: Elaborative	
(E_1) At times, my academic writing has given me deep personal satisfaction	0.714
(E_5) Writing an academic paper helps me develop my ideas	0.697
(E_8) Academic writing helps me organize information in my mind	0.635
Factor 2: Low self-efficacy	
(LS_1) I worry so much about my writing that it prevents me from getting started	0.730
(LS_2) I need special encouragement in order to do my best writing	0.672
(LS_5) Having my writing evaluated scares me	0.530
Factor 3: No revision	
(NR_1) Often my first draft is my finished product	0.766

(NR_2) I do not normally expect to make significant changes to my text by revising it	0.674
(NR_5) Revision is usually a one-time process at the end	0.653
Factor 4: Intuitive	
(I_1) I can hear myself while writing	0.517
(I_3) I visualize what I am writing about	0.549
(I_10) I put a lot of myself in my academic writing	0.560
Factor 5: Scientist	
(SC_1) When faced with an academic paper, I develop a plan and stick to it	0.509
(SC_2) It is important to me to have my argument or ideas clear before writing	0.403
(SC_4) I keep my topic clearly in mind as I write	0.485
Factor 7: Sculptor	
(SR_4) Writing academic papers reminds me of other things that I do	0.527
(SR_5) Academic writing is symbolic	0.496
(SR_6) Originality in writing is highly important in academic writing	0.417
Factor 8: Blocks	
(Blk 1) My previous writing experiences are mostly negative	0.716
(Blk 2) I sometimes get completely stuck if I have to produce texts	0.667
(Blk 5) I hate writing	0.756
Factor 9: Procrastination	
(Proc 1) I often postpone writing tasks until the last moment	0.718
(Proc 3) I find it difficult to start writing	0.718
(Proc 4) I start writing only if it is absolutely necessary	0.799
Factor 10: Perfectionism	
(Perf 1) I find it difficult to write because I am too critical	0.696
(Perf 2) Writing is difficult because the ideas I produce seem stupid	0.562
(Perf 4) I find it difficult to hand over my texts, because they never seem complete	0.692
Factor 11: Innate ability	
(InAb1) The skill of writing is something we are born with; it is not possible for all of us to learn it	0.804
(InAb2) Writing is a skill, which cannot be taught	0.817
Factor 12: Knowledge transforming	
(KTran1) Writing often means creating new ideas and ways of expressing oneself	0.652
(KTran2) Writing develops thinking	0.674
(KTran4) Writing is a creative activity	0.569
Factor 13: Productivity	
(Produ1) I produce a large number of finished texts	0.703
(Produ2) I am a regular and productive writer	0.747
(Produ4) I write whenever I have the chance	0.688

Discussion and Conclusions

The present study presents some limitations. First, the length of the original survey might have influenced the reliability of the data set. Although the number of participants is quite high (N=621), the length of the survey might induce students' lack of concentration or even rush when filling the survey. Second, as participants were compensated with a monetary incentive, there is

the possibility that participants might not be genuine and honest with their answers. While we cleaned the data for participants who answered all the same answer and who did not complete more than two items, this limitation is still a possibility. Third, the study was not designed to separate doctoral students from master's students, nor research-based master's students from "non-thesis" or "coursework-only" master's students. While we sampled graduate students from similar institutions with high research productivity, there may be underlying variation in the sample that is not immediately evident. Therefore, suggestions for future work include performing an Exploratory Factor Analysis on the used data to extract new factors and evaluate if there is some multicollinearity present; validation of the developed short-form survey by collecting a new data set and performing a new statistical analysis; and for future data collection include a uniformity of data subjects, such as similar graduate paths (e.g., doctoral students vs master's students).

Despite these limitations, in this paper, we present a valid short-form survey by which to assess graduate engineering student writing attitudes. This survey now only comprises 35 items and is likely to provide larger sample sizes and more reliable data than the long form survey. Our future goals with this short-form writing attitudes survey include hosting it on the research group's outward-facing website with background programming that will be able to analyze a user's data in real time while also collecting the data for us to analyze. The user will receive the results of their "writing profile" and personalized strategies for writing based on their most dominant writing processes and concepts. Readers wishing to employ this survey in its easy-to-use web interface should contact the research team for access to the survey. We expect that this tool can be easily applied in engineering classrooms and technical communications, and will help us validate the survey for other groups, such as undergraduate students as well as continuing to explore writing attitudes for graduate engineering students. On a broader view, we propose that a major research implication of this study overall is to facilitate students' abilities to communicate their research effectively and more easily decipher the discourse expectations of academic engineering in graduate school.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant 1733594. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

[1] B. Yalvac, H. D. Smith, J. B. Troy, and P. Hirsch, "Promoting advanced writing skills in an upper-level engineering class," *Journal of Engineering Education*, vol. 96, no. 2, pp. 117–128, 2007.

[2] J. A. Leydens, "Novice and insider perspectives on academic and workplace writing: Toward a continuum of rhetorical awareness," *IEEE Transactions on Professional Communication*, vol. 51, no. 3, pp. 242–263, 2008.

[3] "ABET Accreditation Criteria," 2018. [Online]. Available: http://www.abet.org/accreditation/accreditation-criteria/.

[4] American Society for Engineering Education, "Transforming Undergraduate Education in Engineering," Washington D.C., 2013.
[5] P. Zemliansky and L. Berry, "A Writing-Across-the-Curriculum Faculty Development Program: An Experience Report," *IEEE Transactions on Professional Communication*, vol. 60, no. 3, pp. 306–316, 2017.
[6] S. Conrad, "A Comparison of Practitioner and Student Writing in Civil Engineering," *Journal of Engineering Education*, vol. 106, no. 2, pp. 191–217, 2017.
[7] A. Parker, D. Ph, K. Marcynuk, and V. Scholar, "Undergraduate writing assignments in engineering: Targeting Communication Skills (Attribute 7)," pp. 1–5, 2016.
[8] P. O. Jenkins, S., Jordan, M. K., & Weiland, "The role of writing in graduate engineering education: A survey of faculty beliefs and practices," *English for Specific Purposes*, vol. 21, no. 1, pp. 51–67, 1993.
[9] I. M. Hasbun, H. M. Matusovich, and S. G. Adams, "The dissertation Institute: Motivating doctoral engineering students toward degree completion," in *IEEE Frontiers in Education Conference*, 2016, vol. 2016-Novem, p. American Society for Engineering Education (ASEE).
[10] M. Rose and K. A. McClafferty, "A Call for the Teaching of Writing in Graduate Education.," *Educational Researcher*, vol. 30, no. 2, pp. 27–33, 2001.
[11] N. Fang, "A Student-Centered Active Learning Approach to Teaching Grant Proposal Writing in a Ph.D. in Engineering Education Program," *International Journal of Engineering Education*, vol. 28, no. 5, pp. 1168–1176, 2012.
[12] K. Hyland, "Disciplinary discourses: Writer stance in research articles," in *Writing: Texts, Processes, and Practices*, C. N. Candlin and K. Hyland, Eds. New York, NY: Longman, 1999, pp. 99–121.
[13] H. Ding, "The Use of Cognitive and Social Apprenticeship to Teach a Disciplinary Genre: Initiation of Graduate Students into NIH Grant-Writing," *Written Communication*, vol. 25, no. 1, pp. 3–52, 2008.
[14] J. Morton, "Genre and disciplinary competence: A case study of contextualisation in an academic speech genre," *English for Specific Purposes*, vol. 28, no. 4, pp. 217–229, Oct. 2009.
[15] C. Berkenkotter and T. Huckin, *Genre knowledge in disciplinary communities*. Lawrence Erlbaum Associates, Publishers, 1995.
[16] M. Castelló, A. Iñesta, and C. Monereo, "Towards self-regulated academic writing: An exploratory study with graduate students in a situated learning environment," *Electronic Journal of Research in Educational Psychology*, vol. 7, no. 3, pp. 1107–1130, 2009.
[17] H. Mei-ching, "Exploring Writing Anxiety and Self-Efficacy among EFL Graduate Students in Taiwan," *Higher Education Studies*, vol. 6, no. 1, pp. 24–39, 2016.
[18] S. Mcleod, "Some thoughts about feelings: The affective domain and the writing process," *College Composition and Communication*, vol. 38, no. 4, pp. 426–435, 1987.
[19] J. A. Daly, "Writing apprehension," in *When a Writer Can't Write: Studies in Writer's Block and Other Composing-Process Problems*, M. Rose, Ed. New York, NY: The Guilford Press, 1985, pp. 43–82.
[20] A. Badran and W. Instruction, "The Relationship of Writing Apprehension and Self-Esteem to the Writing Quality and Quantity of EFL University Students. Report Research. Faculty of Education, Mansoura University. Mesir," *Eric*, 2001.
[21] L. Z. Bloom, "Anxious writers in context: Graduate school and beyond," in *When a Writer Can't Write: Studies in Writer's Block and Other Composing-Process Problems*, M. Rose, Ed. New York, NY: The Guildford Press, 1985, pp. 119–133.
[22] D. Bartholomae, "Inventing the university," in *When a Writer Can't Write: Studies in Writer's Block and Other Composing-Process Problems*, M. Rose, Ed. New York, NY: The Guildford Press, 1985, pp. 134–165.
[23] A. Onwuegbuzie and K. Collins, "Writing apprehension and academic procrastination among graduate students," *Perceptual and motor skills*, vol. 92, no. 2, pp. 560–562, 2001.

[24] W. Fan and Z. Yan, “Factors affecting response rates of the web survey: A systematic review,” *Computers in Human Behavior*, vol. 26, no. 2, pp. 132–139, 2010.
[25] C. G. P. Berdanier, “Learning the Language of Academic Engineering: Sociocognitive Writing in Graduate Students.” Purdue University, 2016.
[26] E. Lavelle and K. Bushrow, “Writing Approaches of Graduate Students,” *Educational Psychology*, vol. 27, no. 6, pp. 807–822, 2007.
[27] B. J. Zimmerman and A. Bandura, “Impact of self-regulatory influences on writing course attainment,” *American Educational Research Journal*, vol. 31, no. 4, pp. 845–862, 1994.
[28] K. Lonka, A. Chow, J. Keskinen, N. Sandstrom, and K. Pyhalto, “How to measure PhD. students ’ conceptions of academic writing – and are they related to well-being?,” *Journal of Writing Research*, vol. 5, no. 3, pp. 245–269, 2014.
[29] J. A. Daly and M. D. Miller, “Apprehension of writing as a predictor of message intensity,” *Journal of Psychology; Provincetown, Mass., etc.*, vol. 89, no. 2, pp. 175–177, Mar. 1975.
[30] K. J. Bieschke, R. M. Bishop, and V. L. Garcia, “The Utility of the Research Self-Efficacy Scale,” *Journal of Career Assessment*, vol. 4, no. 1, pp. 59–75, Jul. 1996.
[31] C. G. P. Berdanier and E. Zerbe, “Quantitative investigation of engineering graduate student conceptions and processes of academic writing,” in *IEEE Professional Communication Conference (Procomm)*, 2018, pp. 1–8.
[32] C. G. P. Berdanier, “Learning the Language of Academic Engineering: Sociocognitive Writing in Graduate Students.” Purdue University, 2016.
[33] C. G. P. Berdanier and E. Zerbe, “Correlations between graduate student writing concepts and processes and certainty of career trajectories,” in *IEEE Frontiers in Education Conference*, 2018, p. 9.
[34] J. B. Schreiber, A. Nora, F. K. Stage, E. A. Barlow, and J. King, “Reporting Structural Equation Modeling and Confirmatory Factor Analysis Results: A Review,” *The Journal of Educational Research; Bloomington*, vol. 99, no. 6, pp. 323-327,330-337,384, Aug. 2006.
[35] B. T. Chung and S. F. Morris, “Confirmatory Factor Analysis of the Michigan Hand Questionnaire:,” *Annals of Plastic Surgery*, vol. 74, no. 2, pp. 176–181, Feb. 2015.
[36] H. Gatignon, “Reliability Alpha, Principle Component Analysis, and Exploratory Factor Analysis,” in *Statistical Analysis of Management Data*, H. Gatignon, Ed. New York, NY: Springer New York, 2010, pp. 29–57.
[37] T. A. Brown, *Confirmatory Factor Analysis for Applied Research, Second Edition*. New York: Guilford Publications, 2014.
[38] J. L. Arbuckle, *AMOS User’s Guide*. Chicago: IBM SPSS, 2017.
[39] J. DeCoster, “Overview of factor analysis,” 1998.
[40] R. C. MacCallum, M. W. Browne, and H. M. Sugawara, “Power analysis and determination of sample size for covariance structure modeling,” *Psychological Methods*, vol. 1, no. 2, pp. 130–149, Jun. 1996.

Appendix

Inventory of Graduate Writing Processes (Lavelle and Bushrow [26])

Factor: Elaborative
(E_1) 45. At times my academic writing has given me deep personal satisfaction
(E_2) 4. Writing academic papers makes me feel good
(E_3) 46. The main reason for writing an academic paper is just to get a good grade on it
(E_4) 30. Writing assignments in graduate courses are always learning experiences
(E_5) 61. Writing an academic paper helps me develop my ideas
(E_6) 62. Academic writing is cold and impersonal
(E_7) 50. Writing an academic paper is like a journey
(E_8) 44. Academic writing helps me organize information in my mind
(E_9) 58. My intention in writing is just to answer the question
(E_10) 21. Academic papers usually have little to do with what I do in my career or my life
(E_11) 40. Writing an academic paper is making a new meaning
(E_12) 15. I worry about how much time my paper will take

Factor: Low self-efficacy
(LS_1) 53. I worry so much about my writing that it prevents me from getting started
(LS_2) 63. I need special encouragement to do my best academic writing
(LS_3) 13. I can write a term paper without any help or instruction
(LS_4) 56. I do well on tests requiring essay answers
(LS_5) 32. Having my writing evaluated scares me
(LS_6) 64. I can't revise my writing because I cannot see my own mistakes
(LS_7) 35. I like to work in small groups to discuss ideas or to do revision in writing
(LS_8) 49. I expect good grades on academic papers
(LS_9) 27. I am familiar with the components of a research paper or thesis
(LS_10) 18. Writing an essay or paper is always a slow process
(LS_11) 23. Studying grammar and punctuation would greatly improve my writing

Factor: No revision
(NR_1) 60. Often my first draft is my finished product
(NR_2) 66. I do not normally expect to make significant changes to my text by revising it
(NR_3) 41. My revision strategy is usually making minor alterations, just touching things up
(NR_4) 16. I tend to write a rough draft and then go back repeatedly to revise it
(NR_5) 7. Revision is a onetime process at the end
(NR_6) 3. I reexamine and restate my thoughts in revision
(NR_7) 17. Revision is the process of finding the shape of my writing
(NR_8) 51. I plan, write and revise all at the same time
(NR_9) 29. I never think about how I go about writing

Factor: Intuitive
(I_1) 25. I can hear myself while writing
(I_2) 57. I often think about my paper when I am not writing (late at night)
(I_3) 24. I visualise what I am writing about
(I_4) 33. I tend to spend a long time thinking about my writing assignment before beginning
(I_5) 6. I can hear my voice as I reread papers that I have written
(I_6) 36. I imagine the reaction that my readers might have to my paper
(I_7) 5. I closely examine what the essay calls for
(I_8) 31. In my writing I tend to use some ideas to support other, larger ideas
(I_9) 22. It is important to me to like what I have written
(I_10) 28. I put a lot of myself in academic writing
(I_11) 26. My prewriting notes are always a mess
(I_12) 34. When writing a paper, I often get ideas for other papers

Factor: Scientist
(SC_1) 9. When faced with an academic paper, I develop a plan and stick to it
(SC_2) 67. It is important to me to have my ideas or arguments clear before writing
(SC_3) 1. When writing an academic paper, I stick to the rules
(SC_4) 10. I keep my topic clearly in mind as I write
(SC_5) 43. The thesis or main idea is the heart of the academic paper
(SC_6) 2. I set aside specific times to do academic papers
(SC_7) 55. I start with a fairly detailed outline
(SC_8) 54. I like written assignments to be well specified with details included
(SC_9) 12. The thesis or main idea dictates the type of paper to be written

Factor: Task-oriented
(TO_1) 65. When writing an academic paper, my idea or topic often changes as I progress
(TO_2) 39. My writing rarely expresses what I really think
(TO_3) 37. I complete each sentence and revise it before going on to the next
(TO_4) 8. There is usually one best way to write an academic paper
(TO_5) 38. I cue my reader by giving a hint of what is to come
(TO_6) 48. My essay or paper often goes beyond the specifications of the assignment
(TO_7) 47. When given an assignment, I immediately know which side I will take
(TO_8) 42. I am my own audience

Factor: Sculptor
(SR_1) 59. I just write off the top of my head and then go back and rework the whole thing
(SR_2) 11. When writing an academic paper, I tend to write what I would say if I were talking
(SR_3) 52. I usually write several paragraphs before rereading
(SR_4) 20. Writing academic papers reminds me of other things that I do
(SR_5) 19. Academic writing is symbolic
(SR_6) 14. Originality in writing is highly important in academic writing

Graduate Concepts of Academic Writing (Lonka et al. [28])

Factor: Blocks
(Blk 1) Q6. My previous writing experiences are mostly negative
(Blk 2) Q10. I sometimes get completely stuck if I have to produce texts
(Blk 3) Q14. I find it easier to express myself in other ways than writing
(Blk 4) Q15. I only write when the situation is peaceful enough
(Blk 5) Q19. I hate writing

Factor: Procrastination
(Proc 1) Q3. I often postpone writing tasks until the last moment
(Proc 2) Q9. Without deadlines I would not produce anything
(Proc 3) Q11. I find it difficult to start writing
(Proc 4) Q18. I start writing only if it is absolutely necessary

Factor: Perfectionism
(Perf 1) Q5. I find it difficult to write, because I am too critical
(Perf 2) Q24. Writing is difficult because the ideas I produce seem stupid
(Perf 3) Q21. I could revise my texts endlessly
(Perf 4) Q17. I find it difficult to hand over my texts, because they never seem complete

Factor: Innate ability
(InAb1) Q16. The skill of writing is something we are born with; it is not possible for all of us to learn it
(InAb2) Q23. Writing is a skill, which cannot be taught

Factor: Knowledge transforming
(KTran1) Q26. Writing often means creating new ideas and ways of expressing oneself
(KTran2) Q27. Writing develops thinking
(KTran3) Q25. Rewriting texts several times is quite natural
(KTran4) Q4. Writing is a creative activity
(KTran5) Q1. It is useful to get other people's comments on texts
(KTran6) Q2. When I write I am concerned about whether the reader understands my text

Factor: Productivity
(Produ1) Q8. I produce a large number of finished texts
(Produ2) Q20. I am a regular and productive writer
(Produ3) Q7. I write regularly regardless of the mood I am in
(Produ4) Q22. I write whenever I have the chance