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Identification and preliminary review of doctoral theses in engineering education that have used phenomenological methods

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1 INTRODUCTION

This paper presents the design, data collection process, and preliminary findings of an exploratory study that will lead to a more systematic review of phenomenological research in the realm of education regarding engineering and other STEM subjects (i.e., science, technology, engineering and mathematics). This paper identifies doctoral theses and dissertations that have used the method to produce findings. The term "thesis" is used throughout to connotate both "thesis" and "dissertation". The term "phenomenology" is used to mean a research methodology for understanding and describing human experience—by analyzing, interpreting, and synthesizing personal accounts of a phenomenon. Accounts are typically collected via in-depth interviews. Moreover, phenomenology seeks to identify core,

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shared aspects of the experience, or its overall essence. Phenomenologists often assess the texture (what happened while experiencing the phenomenon) and structure (the various ways the phenomenon was experienced by participants). This study represents a work-in-progress and is guided by recommendations for conducting systematic reviews that have been published by recognized scholars in engineering education [1], [2].

The study reported here focuses on a foundational body of gray literature, so that researchers and engineering educators can better understand and make use of this particular knowledge base. Findings of the study are intended for use by education researchers, phenomenological researchers, third-level engineering educators, higher education administrators/managers, and policy makers. Research questions driving the overall study are: *What patterns emerge via systematic review of phenomenological doctoral theses? What demographic groups and range of topics have been explored?*

Work completed to date suggests phenomenological methodologies that phenomenology is being used as a research method more and more frequently in engineering education research (EER), but although they may inform earlier studies, they have been explicitly called out as the formal research methodology only recently in EER. Databases recommended specifically for use in systematic reviews in engineering education [1] provide access to 33 theses, with most of these originating in Higher Education Institutions (HEIs) in the United States. This number is not far behind the number of scholarly journal articles (49) and conference papers (50) identified using the same databases and search constraints.

2 FOCUS OF SYSTEMATIC REVIEW

At the outset of this study, multiple databases were mined to identify publications where "phenomenology" and "engineering education" or "engineering students" or "STEM students" appear in the title, keywords, or abstract. Three types of documents were mined: (1) peer-reviewed journal articles; (2) conference papers; and (3) doctoral-level theses that have been approved by a recognized HEI. The first group is considered the highest form of "scholarly literature" whereas the second and third groups are described as "gray literature" [1]. Gray literature also includes government documents, reports, books, websites, and the like [1]. In emerging fields, publications typically appear in gray literature before they make their way into scholarly journals [3].

Table 1. Yield of database search

Search "phenomenology"	& "engineering education"	& "engineering students"	& "STEM students"	Total
ProQuest (journal articles)	40	Adds 1	Adds 2	43
Scopus (journal articles)	6	Adds 0	Adds 0	06
Scopus (conference papers)	16	Adds 4	Adds 0	20
ProQuest (conference papers)	23	Adds 2	Adds 5	30
ProQuest (theses)	**17**	**Adds 1**	**Adds 1**	**19**
Open Access (theses)	**6**	**Adds 0**	**Adds 8**	**14**

A basic search using *Google Scholar* identified 2750 sources associated with the terms "phenomenology" and "engineering education", 1910 associated with "phenomenology" and "engineering students", and 218 associated with "phenomenology" and "STEM students". A similar search of *Taylor and Francis Online* identified a similarly large number of results

(1561, 1540, and 1670 respectively). To limit the search to items that have been more thoroughly vetted, it was advantageous to specify terms under the "advanced search" options that many databases provide. Results, however, varied widely from one database to the next, with regard to accuracy and applicability. Subsequent searches for this study set the search parameters to identify only instances where the three terms appeared in the title, abstract, or keywords. Although searches using such parameters will identify many relevant sources, they will not identify documents that do not tag these particular terms up front.

3 METHODOLOGY AND DESCRIPTION OF MATERIAL STUDIED

This study used multiple databases to locate basic information on relevant journal articles, conference papers, theses and dissertations. For all these, the researchers collected bibliographic information and full-length abstracts. For the theses, they collected a full set of full-length texts as well. The best databases to use depend upon one's research subject and intent [1]. This study included searches of: the general databases ***JSTOR*** and ***Scopus***; the journal databases ***Science Direct*** and ***ProQuest***; and thesis databases ***ProQuest*** and ***Open Access Theses and Dissertations***. Across these databases, using the terms "phenomenology" and "engineering education" yielded many more results than the other two sets of terms, but the addition of terms "engineering students" and "STEM students" added value to the study by identifying a few texts not found using the primary terms.

4 RESULTS

With regard to journal articles, *Scopus* and *ProQuest* yielded the most plentiful and useful results. Surprisingly, there was no overlap in the results gathered using *Scopus* and *ProQuest*; none of the references located using one appeared in the other. Using *Scopus* and *ProQuest* identified a total of 49 peer-reviewed scholarly journal articles. Publications not relevant to this investigation were excluded manually (e.g., those using phenomenography rather than phenomenology). Phenomenology focuses on pre-reflective, raw experience and identifying shared that summarize the essence of the experience, whereas phenomenography focuses on different categories of conceptualization and is thus post-reflective; these two methods are quite different.

Two additional databases were searched without yielding useful journal results. Although *JSTOR* identified some relevant resources, it did not add any items beyond those already identified using *Scopus* and *ProQuest*. *Science Direct* did not identify any relevant results. Since *Scopus* and *ProQuest* provided good access to vetted conference papers, we harvest basic data about these as well, for use in future analyses.

In keeping with expert recommendations [1], thesis searches were conducted using *ProQuest* and *Open Access Theses and Dissertations* (shown in boldface in Table 1), with a yield of 33 relevant theses. All results identified by *ProQuest* came from HEIs in the United States and were published between the years 2009 and 2016. *ProQuest* was established in Michigan in 1938, and this helps suggest in the US, phenomenology is now emerging in EER. Initial searches using *Open Access* were unsuccessful, so follow-up searches were conducted manually. Since tightly controlled searches yielded no results, searches were run without " " surrounding search terms, yielding identification of 109 theses. Those focused on phenomenology in education (rather in than technical, physics-related terms) were harvested from the list manually. Only 14 fit the requirements of this study. Of these, 6 matched the primary terms of phenomenology and engineering education. Eight more had to do with

STEM more broadly, including two from Architecture and Built Environment. *Open Access* provided greater diversity in dates (2003-2017) and origin (with 5 written outside the USA). This implies manual cultivation of other database searches could increase yield (Table 1).

Table 2. ProQuest Demographic and Institutional Information of Researchers

Author's Name	Year	Lev.	Sex	Institution	School/Area
Benedict-Augustine	2010	EdD	F	Univ. of Pennsylvania	Higher Educ. Management
DeRamus-Suazo	2012	PhD	F	Capella University	School of Education
Ecklund	2013	PhD	M	Colorado State Univ.	School of Education
Frillman	2011	PhD	F	Purdue University	School of Engineering Educ.
Luo	2014	PhD	F	Purdue University	School of Engineering Educ.
Masterman	2014	PhD	F	Boston College	Department of Educ. Leadership & Higher Educ.
McDonald	2016	PhD	F	University of Utah	Department of Educational Leadership and Policy
McNeill	2013	EdD	M	Northcentral Univ.	School of Education
Mena	2010	PhD	F	Purdue University	School of Engineering Educ.
Parker	2013	PhD	F	UNC Charlotte	Curriculum and Instruction
Richards	2009	PhD	M	Purdue University	School of Engineering Educ.
Spaulding	2013	EdD	M	Fielding Graduate University	Somatics, Phenomenology, & Communicative Leadership
Strutz	2012	PhD	F	Purdue University	School of Engineering Educ.
Sun	2012	PhD	F	Purdue University	School of Engineering Educ.
Torres Ayala	2012	PhD	F	University of South Florida	Curriculum and Instruction, College of Education
Troesch	2015	PhD	F	Michigan Tech. Univ.	Rhetoric, Theory and Culture
Verdan	2012	PhD	F	Clemson University	Chemistry
White	2014	PhD	F	Capella University	School of Engineering Educ.
Zhu	2013	PhD	F	Purdue University	School of Engineering Educ.

This section tabulates results as recommended by [2]. Tables facilitate comparison of results between *ProQuest* (Table 2) and *Open Access* (Table 3). These two tables identify each author's name, year of graduation, degree earned, gender or sex (as identified using name recognition, university website, and LinkedIn profiles), HEI granting the degree, and the School or academic area named in the title page of the thesis.

Table 3. Open Access Demographic and Institutional Information of Researchers

Author	Year	Level	Sex	Institution	School/Area
Alkhadrawi	2015	PhD	F	University of Toledo	Curriculum and Instruction
Darrow	2012	PhD	F	Iowa State University	Education (Educ. Leadership)
Foulcher	2017	PhD	M	Univ. of Newcastle	School of Architecture & Built Env.
Gardner	2017	PhD	F	Syracuse University	Teaching and Leadership
Heroux	2012	PhD	F	Loyola Univ. Chicago	Education
Howard	2003	PhD	M	Pennsylvania State Univ.	Workforce Educ. & Development
Mabovula	2002	MEd	F	Rhodes University	Education
Marais	2014	M	F	University of South Africa	Master of Commerce (industrial and

					organisational psychology)
McCann	2013	PhD	F	University of Oklahoma	Instructional Leadership & Academic Curriculum
Pan	2014	PhD	F	University of Maryland	Education Policy and Leadership
Subryan	2017	PhD	F	University of Derby	Education
Thackeray	2016	EdD	F	Northeastern University	School of Education
Troesch	2015	PhD	F	Michigan Tech. University	Department of Humanities
Tuapawa	2017	PhD	F	University of Newcastle	School of Architecture & Built Env.

Table 4 facilitates comparison of the engineering subjects studied (which are underlined). Sample demographics, sample size, and research method often do not appear in the title.

Table 4. Comparison of Titles and Topics

ProQuest	Open Access
Benedict-Augustine, A. (2010). *The impact of international internships on undergraduate college students' career development.*	Alkhadrawi, A. A. (2015). *Gender differences in math and science choices and preferences.*
DeRamus-Suazo, N. (2012). *The influence of college choice on the success, ethnic identity, and professional sense of belonging of African American engineers.*	Darrow, M. E. (2012). *Engineering transfer student leavers: Voices from the sidelines of the engineering playing field.*
Ecklund, A. P. (2013). *Male engineers: An interpretive phenomenological analysis of the experiences of persistence in higher education*.	Foulcher, N. C. (2017). *The tale of two schools: Design technology, digital mediation and aesthetic dispositions within architectural design education.*
Frillman, S. A. (2011). *A hermeneutic phenomenological study of the experiences of female African American undergraduate engineering students at a predominantly white and an historically black institution*.	Gardner, M. (2017). *Understanding integrated STEM science instruction through the experiences of teachers and students.*
Luo, Y. (2014). *Use of Web 2.0 technologies: A virtual ethnographic and phenomenological study of first-year engineering students' experiences*.	Heroux, K. H. (2012). *How do secondary science teachers understand and implement technological design in their classrooms?*
Masterman, A. K. (2014). *Women's doctoral student experiences and degree progress in education versus engineering*.	Howard, C. A. (2003). *From engineer to manager: A qualitative study of experiences, challenges, and individual transitions for engineering managers in aerospace companies.*
McDonald, L. K. (2016). *"You have no life other than that, so you better like what you're doing": A feminist phenomenology of women in undergraduate engineering majors.*	Mabovula, N. (2002). *A phenomenological investigation of a female leader's perceptions and experience of discrimination in the work place.*
McNeill, D. G. (2013). *Industry driven electronic communication competencies for an associate electronics degree: A phenomenological study*.	Marais, M.-H. (2014). *Retention and engagement of generation Y engineers: A hermeneutic phenomenological inquiry.*
Mena, I. B. (2010). *Socialization experiences resulting from engineering teaching assistantships at Purdue University*.	McCann, F. (2013). *Engineers' self-perceptions and a strategy for fostering authentic images of engineers and scientists among elementary school students.*
Parker, A. D. (2013). *Family matters: Familial support and science identity formation for African American female STEM majors.*	Pan, Y. (2014). *Transcendence of time and space: The lived experiences of Chinese international graduate students in the United States.*
Richards, G. P. (2009). *Relating engineering technology students' experiences in electromagnetics with performance in communications coursework: A mixed-methods*	Subryan, S. (2017). *Exploring secondary school science teacher professional identity: Can it be influenced and reshaped by experiences of professional development programmes?*

study.	
Spaulding, R. J. (2013). *An alternative expert knowledge transfer model: A case study of an indigenous storytelling approach*.	Thackeray, S. L. (2016). *Overcoming the toxic influence of subtle messaging: Utah women who persist in STEM.*
Strutz, M. L. (2012). *Influences on low-SES first-generation students' decision to pursue engineering*.	Troesch, V. (2015). *What is it to be an ethical engineer? A phenomenological approach to engineering ethics pedagogy*.
Sun, Y. (2012). *Investigating the learning to teach process: Pedagogy, innovation adoption, expertise development, and technology integration*.	Tuapawa, K. (2017). *An interpretation of key stakeholders' experiences using educational online technologies in blended tertiary environments: A phenomenological study.*
Torres Ayala, A. T. (2012). *Future engineering professors' conceptions of learning and teaching engineering*.	**Other relevant theses**
Verdan, A. M. (2012). *Finding a new continent versus mapping all the rivers: Recognition, ownership, and the scientific epistemological development of practicing scientists and engineers*.	Chari, D. (2014). *What is nanoscience?'-A hermeneutic phenomenological study of nanoscience researchers' experiences*. (PhD, Dublin Institute of Technology).
White, S. M. (2014). *The experiences of women engineers who have completed one to five years of professional engineering employment: A phenomenological study*.	Charity-Leeke, P. C. (2012). *Women in engineering: A phenomenological analysis of sociocultural contextual meaning of gender roles.* (PhD, Cleveland State University).
Zhu, J. (2013). *Personal epistemological development of Chinese engineering doctoral students in U.S. institutions: An application of Perry's theory*.	Kuzmak, N. (2010). *Women engineers: Stories of persistence.* (PhD, Capella University).
	Somerville-Midgette, K. N. (2015). *An engineering journey: A transcendental phenomenological study of African-American female engineers' persistence.* (EdD, Liberty University).

5 DIRECTION OF UPCOMING RESEARCH

Using a system such as this can facilitate comparison. Although analysis is in very early stages, Tables 5 and 6 suggest directions for future work. Table 5 suggests one format, with presentation of focused data.

Table 5. Tabulation of Focused Data

Author	Sample Demographic	#	Focus of Study
Benedict-Augustine	Undergrads & support professionals in business, engineering, liberal arts	20	Impact of international internships on undergraduates' career development
DeRamus-Suazo	African-American engineers	8	Influence of college choice (HBCU vs. PWI) on sense of success, ethnic identity, professional belonging
Ecklund	Male engineering undergrads	12	Experiences of persistence in higher education
Frillman	Female African American engineering undergrads	19	Experiences at demographically different HEIs (one HBCU and one PWI)
Masterman	Female doctoral students (10 in the field of Education and 11 in Engineering).	21	Doctoral education culture in Education and Engineering and how these cultures influence women's student experiences and their degree progress
McDonald	Female engineering undergrads	7	How participants made meaning of challenging major, being one of a few women, and seeking fulfillment

The format used in Table 6 provides more detailed information, including sample group (size and demographic characteristics), framework and/or focus, and primary findings.

Table 6. Tabulation of More Detailed Data

Source **Sample Number and Criteria**	**Framework or Focus**	**Major Findings**
DeRamus-Suazo, N. (2012). The influence of college choice on the success, ethnic identity, and professional sense of belonging of African American engineers. 8 African-American eng. grads. from Historically Black College/ Univ. (HBCU) or Predominately White Institution (PWI) in USA	Two foci: (1) How college choice influenced success, ethnic identity, sense of belonging, and (2) if participants "favorably viewed their choice of HBCUs versus PWIs" after experiencing practice.	Whether from an HBCU or PWI, participants felt achievement and competence to succeed. Most would choose their HEI again and said it supported their professional aspirations. Sense of belonging and a supportive network (of peers and faculty) influenced participants' outlook. Several described conviction to become an engineer despite challenges faced at HEI and in workforce.
Ecklund, A. P. (2013). Male engineers: An interpretive phenomenological analysis of the experiences of persistence in higher education. 12 male undergrads in one private university in Texas in mechanical, electrical, or computer engineering	Used interpretative phenomenological analysis (IPA) with Tinto's theory of presistence. Focused on HEI experiences to build upon findings of Kuzmak (2010).	Preparation before university was important to persistence, as were having/building a strong network of support, and "being grounded in academic skills and characteristics" (Ecklund, 2013, p. iii). Discussions of persistence involved both intrinsic and extrinsic motivations.
Luo, Y. (2014). Use of web 2.0 technologies: A virtual ethnographic and phenomenological study of first-year engineering students' experiences. 15 first-year engineering students at Purdue Univ. (Indiana, USA)	Methods to study use of Web 2.0 technologies: (1) virtual ethnographic inquiry regarding its use in daily life, and (2) phenomenology regarding its use in (a) formal and (b) informal learning communities.	Web 2.0 tools were important in facilitating the interaction among first-year engineering students in multiple communities, including informal engineering-related communities, online communities for first-year engineering students at Purdue, and for communities
Parker, A. D. (2013). Family matters: Familial support and science identity formation for African American female STEM majors. 10 female African-American STEM undergrads from public HEIs in North Carolina (1 PWI, 1 HBCU)	Using critical race feminism to investigate how family and science identity influence "persistence in STEM while considering the duality of African American women's status in society."	Families and science identity formation influenced STEM experiences of participants. Five themes were identified: (1) independence, (2) support, (3) pressure to succeed, (4) adaptations, and (5) race and gender.
McNeill, D. G. (2013). Industry driven electronic communication competencies for an associate electronics degree: A phenomenological study. 11 applied electronic technology and/or engineering (ETE) professionals	Qualitative phenomenological study using "a modified van Kaam method" and perspectives of curricular improvement	This study identified 12 competencies an applied ETE curriculum should develop in graduates. Results indicated most graduates of applied ETE associate programs lack adequate computer related skills and comprehension of ECTE systems.
Mena, I. B. (2010). Socialization experiences resulting from engineering teaching assistantships at Purdue Univ. 28 engineering doctoral students who worked as teaching assistants	What socialization experiences engineering doctoral students report going through as a result of being engineering TAs	Participants characterized socialization experiences related to: training, interacting various groups, undertaking responsibilities, balancing teaching and research, and developing skills. Experiences varied on multiple factors.

6 DISCUSSION

Despite being “gray literature”, doctoral theses proved to be essential resources in assessing the use of phenomenology in EER. The exploratory results were greatly limited by the search terms and databases used. Searches using two of the best-known thesis databases, *ProQuest* and *Open Access Theses and Dissertations*, failed to identify theses the authors had previously studied and found relevant to the topic. These databases appear to have strong US and English-language bias, with research from other locations and other languages not well represented. Future searches could include European-specific databases and other databases recommended by [1], such as *Academic Search Complete*, *Wiley*, and the *Directory of Open Access Journals* and education-specific databases *ERIC* and *Education Full Text (EBSCO)*.

Current search terms may be too limited. Researchers may have used terms such as “engineering pedagogy”, “engineering didactics”, or “engineering learning” which in Europe are seen as synonymous with “engineering education”. “STEM” is a fairly new term, not common in the past. Identification of phenomenological work proves difficult. Upon closer analysis it may be found that some of the studies located are more phenomenographical than phenomenological. Some researchers may have been inspired by phenomenology but have used some other specialized terms. Researchers inspired by phenomenology may not have prioritized the methodology in their front descriptors; they might not have listed the word in the title, keywords, or abstract even when they used it in a study. Snowball sampling [1] would be necessary for conducting a comprehensive review, if one were aiming to identify all relevant publications with relevant findings pertaining to the specified terms.

Nevertheless, this exploratory study has identified HEIs, mostly in the US, generating phenomenological EER at the doctoral level as well as the range of dates (2003-2017, increasing steadily in recent years), and favoured topics of phenomenological EER enquiry (frequently race and gender, but sometimes the experience of a particular technology or pedagogical approach). A big lesson is that persistence is required in systematic reviews.

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